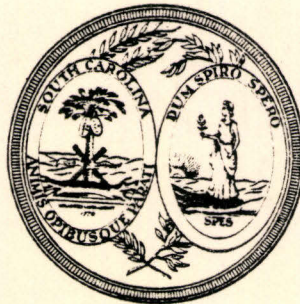


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A REPORT TO THE GENERAL ASSEMBLY
ON GROUND-WATER CONTAMINATION
IN SOUTH CAROLINA



By

James M. Ferguson
Patrick A. Shirley
Suzanna M. Workman

South Carolina Department of Health and Environmental Control
Ground Water Protection Division

February, 1983

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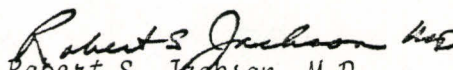
The Honorable Michael R. Daniel
Lieutenant Governor of South Carolina
P.O. Box 142
Columbia, S.C. 29202

Sir:

The South Carolina Department of Health and Environmental Control is pleased to submit the enclosed "Report to the General Assembly on Ground-Water Contamination in South Carolina" as requested by Senate Resolution, Calendar No. S. 1041, dated May 25, 1982.

The recognition given to ground water in the resolution is a positive step toward protecting the State's plentiful, high-quality underground drinking water and the Department of Health and Environmental Control looks forward to implementing any future directives of the General Assembly in this regard.

Respectfully yours,


Robert S. Jackson, M.D.
Commissioner

RSJ/DAD/km

Enclosure

A REPORT TO THE GENERAL ASSEMBLY
ON GROUND-WATER CONTAMINATION
IN SOUTH CAROLINA

By

James M. Ferguson
Patrick A. Shirley
Suzanna M. Workman

South Carolina Department of Health and Environmental Control
Ground Water Protection Division

February, 1983

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I. PREFACE

The South Carolina Department of Health and Environmental Control (DHEC) has prepared this document pertaining to ground-water contamination in South Carolina in response to South Carolina State Senate Resolution, Calendar No. S. 1041 (Figure 1). The Department understands that all persons do not have an equal understanding of the ground-water resource; therefore, a general discussion of South Carolina's ground water and hydrogeology is included for information and precedes the requested reports on:

- Citations of significant sources of potential ground-water contamination;
- Documentation of the current status of ground-water contamination;
- Recommended strategies to protect the State's ground-water quality.

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JUN 23 1982

GROUND-WATER
PROTECTION DIVISION

Calendar No. S. 1041

By SENATOR GARRISON

S. Printer's No. 455—S.

Introduced May 25, 1982.

A SENATE RESOLUTION

To Request the Department of Health and Environmental Control to Report to the General Assembly by the Beginning of Its 1983 Session Certain Information Pertaining to Groundwater Contamination.

Whereas, the Senate recognizes the unique economic value of groundwater as a source of drinking water for approximately sixty-five percent of the State's population; and

Whereas, the Senate recognizes the importance of groundwater to industry and agriculture; and

Whereas, the Senate believes that groundwater resources are a most valuable public resource and as such demand the exercise of good stewardship; and

Whereas, the Senate recognizes the benefits of exercising a high level of protection of groundwater from contamination; and

Whereas, technology now exists whereby waste materials may be satisfactorily stored and disposed of in ways which will not jeopardize the purity of groundwater supplies. Now, therefore,

Be it resolved by the Senate:

That the Senate hereby requests the Department of Health and Environmental Control to report to the General Assembly by the beginning of its 1983 session information concerning:

- (1) citations of significant sources of potential groundwater contamination;
- (2) documentation of the current status of groundwater contamination;
- (3) recommended strategies to protect the State's groundwater quality.

Be it further resolved that a copy of this resolution be forwarded to the Commissioner of the Department of Health and Environmental Control.

—XX—

Figure 1. SENATE RESOLUTION

II. EXECUTIVE SUMMARY

The South Carolina Senate, recognizing the importance of ground water and the fact that its contamination is essentially permanent, has requested that the South Carolina Department of Health and Environmental Control (DHEC) report certain information pertaining to ground-water contamination. The importance of protecting ground-water quality in South Carolina lies in the fact that approximately 60 percent of the population drinks ground water, mostly untreated. It has recently become obvious, because ground water lacks visibility, that it has been ignored and abused, and that correcting the mistakes of the past is nearly impossible. Prevention of ground-water pollution is far more cost effective than after-the-fact abatement.

As background for understanding ground-water contamination and the possible consequences, a general understanding of hydrogeology is necessary. Hydrogeology can be defined as the study of ground water with particular emphasis given to its chemistry, mode of migration, and relation to the geologic environment. The geologic formations which store and yield ground water are aquifers which can be artesian (confined) or water-table (unconfined). An aquifer is generally recharged (replenished) by infiltrating precipitation in its recharge area where it is near the land surface. In the recharge area, any contaminants introduced into the subsurface can enter the aquifer. Ground water slowly flows through the aquifer from the recharge area toward the surface-water discharge area or to wells. Since ground water discharges to surface-water bodies and since surface water can enter aquifers, the two must be jointly considered.

Six major aquifer systems have been designated in South Carolina:

- Shallow Water-Table Aquifer System which occurs statewide
- Igneous and Metamorphic Bedrock Aquifer System which occurs in the entire Piedmont
- Tertiary Sand Aquifer System in the Upper Coastal Plain
- Tertiary Limestone Aquifer System in the Lower Coastal Plain
- Black Creek/Peedee Aquifer System in the eastern and central Lower Coastal Plain
- Middendorf Aquifer System in the entire Coastal Plain.

These aquifers overlap and vary greatly in productivity and water quality, however, all are suitable and meet the federal criteria as "underground sources of drinking water".

The significant sources of potential ground-water contamination categorically include the following activities:

- Disposal of wastes such as sewage, sludges, and industrial wastewaters on the land surface
- Accidental spills of petroleum products and hazardous materials
- The improper use of fertilizers and pesticides
- The leaching of animal wastes from feedlots
- The stockpiling of wastes and raw materials
- The infiltration of polluted surface water
- The burial of wastes (landfills)
- The storing of wastes and raw materials in surface impoundments

- The disposal of household wastes by septic tanks
- The storage of petroleum products and raw materials in buried tanks
- The artificial recharge of aquifers
- The loss or disposal of liquids through sumps and dry wells
- The burial of large numbers of animal bodies
- The injection of wastes into wells
- The overpumping of wells (aquifer depletion)
- The improper construction and abandonment of wells
- The storage of wastes and raw materials in deep excavations

The assignment of relative significance to the activities is complex and subjective. The more serious threats to ground-water quality in South Carolina are considered to be: surface impoundments; landfills; underground tanks and pipelines; land disposal of wastes; and accidental spills.

The current status of ground-water contamination in South Carolina is that the quality is predominantly excellent, except that there are numerous local contamination incidents, which vary greatly in scale and severity. Since 1975, DHEC has discovered 157 such occurrences of ground-water contamination. Ninety water-supply wells are known to have been abandoned as sources of drinking water because of contamination.

The recommended strategies to protect the State's ground-water quality are presented, recognizing the complexity of interrelationships, both technical and administrative. The recommendations, therefore, are presented in two contexts. The first dealing with immediately available options which could be accomplished through existing programs without major modifications. The second dealing

with longer-range, more controversial options which would require considerable promotion and legislation.

In the area of modifying existing programs, South Carolina appears to be in a good position in that the statutory authority to prevent pollution is centered in one agency (DHEC), which facilitates State and Federal coordination. Because adequate regulatory programs have evolved or because the potential threat is minimal, no changes are recommended for: land disposal of wastes; animal feedlots; stockpiles; infiltration of polluted surface water; surface impoundments; and graveyards. For accidental spills, a simple procedural change in the implementation of emergency response protocol is necessary with the goal of minimizing ground-water impact. The regulation of pesticides and fertilizers requires more coordination between Clemson University and DHEC. The landfilling of non-hazardous waste calls for strict adherence to existing ground-water-protection provisions, encouraging conservation and resource recovery in lieu of burial of waste in landfills. For septic tanks, a regulatory modification is needed to provide for the consideration of the collective impact of septic tanks. New regulations controlling future storage tanks and pipelines are required, and underground leaks from existing facilities should be treated with the same level of effort as surface spills. Artificial recharge, sumps and dry wells, and injection wells can best be controlled through the proposed regulations of the federally mandated Underground Injection Control Program implemented by DHEC. Extremely close coordination is needed between

DHEC and Water Resources Commission regarding water-supply wells and overpumping in capacity-use areas. A single permit, issued by DHEC with appropriate input from Water Resources Commission, is the most effective method of reducing burdensome and sometimes conflicting permit conditions. A management goal, regarding an acceptable water-level decline, is needed in both capacity-use areas. Ground-water data collection and storage, currently conducted by DHEC and Water Resources Commission (and U.S. Geological Survey) for economic reasons should be consolidated into the existing computer capabilities of DHEC, through EPA's STORET system which would facilitate compliance with federal reporting requirements. An additional regulation, pursuant to the Pollution Control Act, is needed to control the ground-water-contamination aspects of underground storage.

In a broader perspective, there are several overriding strategic elements, crossing the lines between the previously discussed activities, which are considered essential for the proper protection of the ground-water resource. The first need has been fulfilled by the Senate Resolution, recognizing the unique economic value of ground water and the benefits of exercising a high level of its protection. The absence of a well-defined goal, which clearly has as its purpose the protection of ground-water quality, is a major obstacle, rooted in the hodgepodge of federal laws dealing with ground water. The shift of federal responsibility back to the states provides an excellent opportunity for South Carolina to establish its own goals and carry out a comprehensive ground-water-protection program suited to the needs of South Carolina.

The recommended program should be built around three basic points. First, the highest priority should be assigned to the preservation of high-quality aquifers. Second, the water-quality objective for such aquifers should be non-degradation. Finally, the major mechanism for achieving the non-degradation of high-quality aquifers should be the regulation of land use to prohibit polluting activities within critical recharge zones.

III. ACKNOWLEDGEMENTS

The writers wish to acknowledge Mr. Lynn Shirley, University of South Carolina Geography Department for assistance provided in the computer map preparation, Ms. Nancy H. Trotter for her patience in typing this report and Mr. Raymond L. Knox for assistance provided in the discussion of critical recharge zones.

IV. INTRODUCTION

Ground water is a vast natural resource of incomparable economic importance to agriculture, industry, and everyday life. Because ground water lacks visibility, it is difficult to understand and easy to forget. Ignorance has led to its abuse, and this abuse to the endangering of critical supplies.

Ground water constitutes 97 percent of the planet's supply of unfrozen fresh water. In the United States, ground water accounts for 80 to 90 percent of the available water supply, most of it consumed without treatment, and it is the source of drinking water for approximately 50 percent of all U.S. residents. Drinking water accounts for about 18 percent of the fresh ground water withdrawn

each year. Ground water is relied upon for drinking water to different degrees throughout the nation, but more so in rural than in urban areas. The U.S. Environmental Protection Agency (EPA) has estimated that 96 percent of all rural drinking water comes from ground-water sources, in contrast to 20 percent of urban needs. Likewise in South Carolina, ground water accounts for practically all domestic drinking water in rural areas. Approximately 60 percent of South Carolina's population utilize ground water as a source of drinking water and of the approximately 2500 public water systems, 2400 use ground water.

Ground water has always been thought of as a pristine resource. Recent information, however, reveals that in many locations, ground water is contaminated. Data show that this contamination comes from different sources and includes a variety of materials. These substances, some toxic, are increasingly being found in ground water and, because ground water is widely used for drinking purposes, often pose unacceptable risks to human health.

The massive national pollution cleanup effort associated with landmark environmental legislation of the early 1970's largely ignored ground water and, in fact, probably increased ground-water contamination by encouraging diversion of pollutants from the air and surface waters to the ground.

Correcting ground-water contamination is time-consuming, expensive, and, in many cases, virtually impossible. All in all, prevention of ground-water pollution is far more cost-effective than after-the-fact abatement. The only satisfactory long-range control strategy for the protection of the quality of the State's

ground-water resources is pollution prevention through sound management programs.

In order to understand ground-water contamination and the possible consequences, it is first necessary to present some background on the nature of our ground-water resources.

A. Introduction to Hydrogeology

Hydrogeology can be defined as the study of ground water with particular emphasis given to its chemistry, mode of migration, and relation to the geologic environment. Ground water may be defined as subsurface water that occurs beneath a water table or potentiometric surface in soils or rocks or in geologic formations that are saturated. Aquifers, the subsurface permeable formations which contain ground water and which can yield significant amounts of water to wells and springs, underlie most of the nation. The usable amount of ground water an aquifer will yield depends on its permeability (the amount of water that it can deliver, per unit-area, for a fixed amount of time) and its porosity (the ratio of open spaces in the formation to the total rock volume). (Burmester, 1982).

The two types of aquifers are termed unconfined and confined (Figure 2). Hydrologically these aquifers act in considerably different manners. An unconfined or water-table aquifer is one in which the water table, or free water surface, forms the upper boundary and is under atmospheric

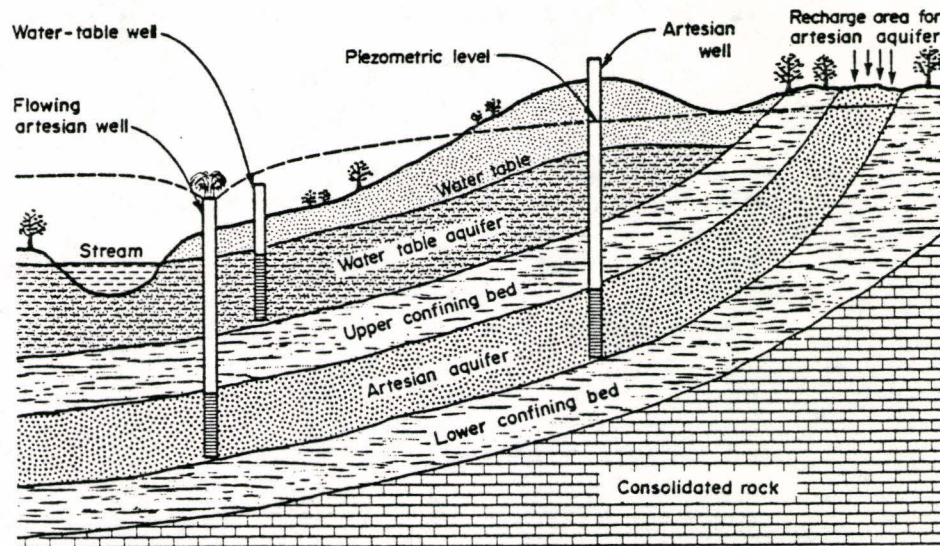


Figure 2. Ground-water phase of the hydrologic cycle.
(From Johnson, 1960, p. 17)

pressure. The water level in a well in an unconfined aquifer rests at the water table. A confined or artesian aquifer is one that is confined between two aquitards (formation of low permeability). The water in a confined aquifer is under hydrostatic pressure and will rise in a well to a point above the top of the aquifer. Generally confined aquifers occur at depth and unconfined aquifers near ground surface (Freeze and Cherry, 1979).

Aquifers are generally recharged by infiltrating precipitation. The "recharge zone" of an aquifer is that land surface area where the aquifer is at the surface (outcrop area) or near the surface (subcrop area) in which water (i.e., infiltrating precipitation) is regularly added to the aquifer. Pollutants may be carried into the aquifers through recharge

zones. The intensity of the recharge, the size of the recharge zone relative to the size of the aquifer, and the extent to which the recharge zone has clear boundaries may vary considerably. Ground water flows under the influence of gravity from the recharge zone toward eventual discharge either naturally to surface waters or through wells at a rate dependent on many hydrologic factors. Flow rates through aquifers are generally extremely slow compared to the movement of surface water; tens to thousands of years may pass between the time of recharge and the time of discharge. Contaminants that enter an aquifer move in the direction of the overall ground-water flow, generally forming an elongated contamination plume that disperses slowly. The dimensions (length/width/depth) of such contamination plumes can be determined by drilling and sampling wells, surface geophysics, and other data-collection methods which, when interpreted with the geology of the area, can be used to predict the ultimate fate of the contaminated ground water. The significance of the contamination is dictated by the nature and concentration of the contaminants, the dimensions of the plume (especially the depth), and its ultimate fate.

Understanding several hydrologic facts is crucial to effective ground-water management. First, since ground and surface waters are connected, each cannot be considered in total isolation from the other; polluted ground water will in most cases discharge eventually to the surface, and polluted surface waters can, in some cases, contaminate ground water.

Second, because ground water has such low rates of flow and dispersion, the nature of and possible remedies for its pollution are singular. On the one hand, pollution of a portion of an aquifer need not have any effect on safe use of the rest of the aquifer. Conversely, once an aquifer section is polluted, it may remain polluted indefinitely, even if the source of pollution is removed. Though the water may be treated at the time of withdrawal, cleanup of the aquifer itself is difficult and usually prohibitively expensive.

B. Introduction to Ground Water in South Carolina

South Carolina has been divided into three major physiographic provinces; the Blue Ridge, Piedmont, and Coastal Plain (Figure 3). Within the three physiographic provinces of South Carolina occur six major aquifer systems. All six aquifer systems meet the state definition for an Underground Source of Drinking Water. In South Carolina, an "underground source of drinking water" means an aquifer or its portion:

- (1) Which supplies any public water system; or,
- (2) Which contains a sufficient quantity of ground water to supply a public water system; and,
 - (a) Currently supplies drinking water for human consumption; or,
 - (b) Contains water with fewer than ten thousand milligrams per liter total dissolved solids.

The following discussion of hydrogeology of South Carolina is derived primarily from the work of Harris and Ferguson (1978) and Padgett and Hardee (1982).

The Blue Ridge province in South Carolina occurs only in the northwestern corner of Oconee County. The rocks of the Blue Ridge province consist primarily of granite and metamorphosed schists and gneisses that have been folded and faulted. The ground water in this area is generally excellent but it may be vulnerable to pollution from surface sources.

Fractures in bedrock exposed at the surface where there is little or no soil mantle (saprolite) provide an easy route for contaminants to enter the ground-water system, since infiltration is rapid and there is little or no opportunity for renovation. The soils in this area are not uniform and vary with slope, depth and drainage. The subsoil and depth to bedrock are highly variable, depending on location, parent-rock type, and weathering.

The Piedmont province comprises the area from the Blue Ridge to the Upper Coastal Plain (Figure 3). The rocks in the Piedmont consist of varied degrees of metamorphosed folded and faulted schists, phyllites and gneisses intruded by granites and cut by diabase and diorite dikes.

The Piedmont soils are generally thicker than the Blue Ridge soils and vary in composition with the parent bedrock from which they have weathered to form saprolite. Depth to bedrock varies from surface outcrop to as much as 100 feet. Ground-water contamination may occur when fractured rock is at the surface or when soil and saprolite have been removed or penetrated by surface water. Ground water in the Piedmont is generally of excellent quality and related to the rock type in which it occurs.

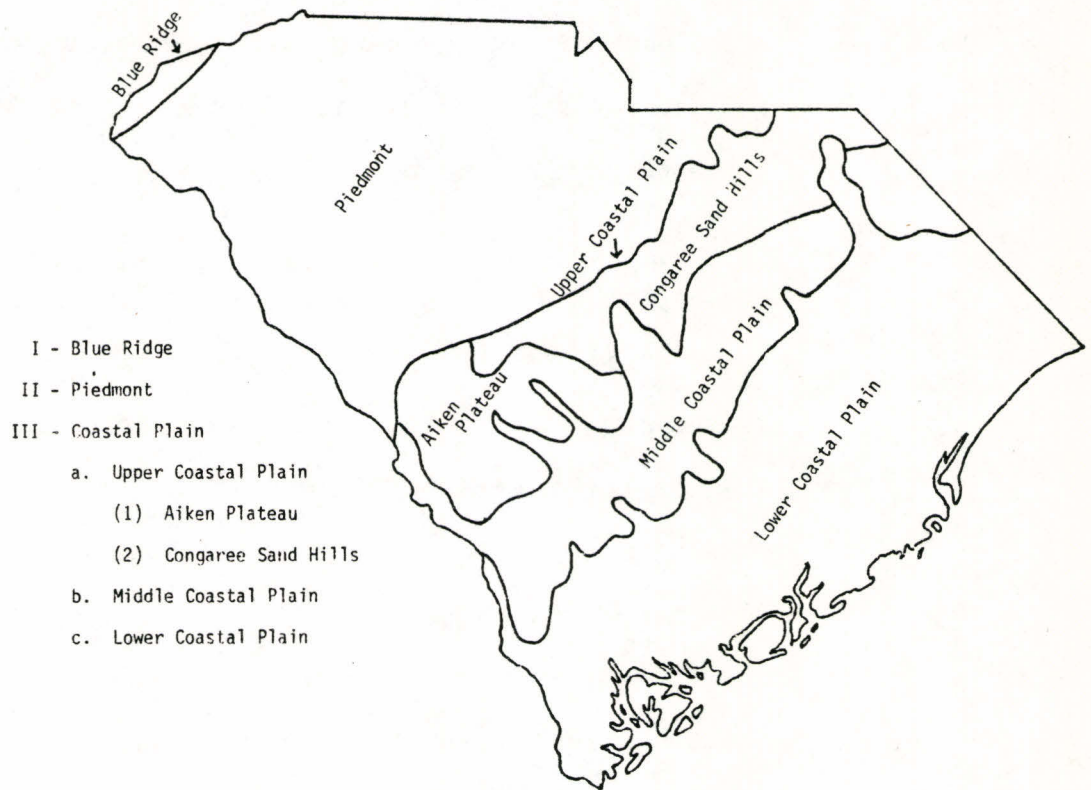


Figure 3. Map of the physiographic provinces of South Carolina.

The Coastal Plain physiographic province is divided into three Regional provinces, the Upper, Middle, and Lower Coastal Plain which lie between the Piedmont and the Atlantic Ocean (Figure 3). The Upper Coastal Plain comprise two subprovinces, the Aiken Plateau and the Congaree Sand Hills, both of which consist of fluvial and eolian sediments and varying percentages of quartz sand and gravel mixed with silt and kaolinitic clay. Wells in the Sand Hills area are drilled into the permeable-sand sections in the sediment or into the fractured crystalline rocks which underlie the sediment. Water quality in the sediment of the Upper Coastal Plain is

excellent for most usages with very low total dissolved solids, is soft and acidic, with localized excessive iron concentrations. The permeable conditions in the upper soil profile in the Sand Hills area create a potential hazard to ground water in that any contaminant which falls on the ground or which is disposed of in sandy areas will rapidly percolate to the water table. The contaminated water may then move with the shallow ground-water flow, without the opportunity to be renovated by a more clayey soil which allows for better filtration, ion exchange, and sorption of contaminants.

The sediments associated with the Middle and Lower Coastal Plain are sand, silt, gravel, shale, marl, clay, and limestone. The sedimentary section thickens to the southeast to about 4,000 feet thick in the Beaufort-Hilton Head area.

The unconsolidated and semiconsolidated sediments of the Coastal Plain store vast amounts of potable ground water and are utilized for domestic, industrial, irrigation, and public water supply systems. Similar to the Upper Coastal Plain, the surficial soils are more permeable in the Middle and Lower Coastal Plain and the shallow water-table aquifer, which is used mainly for domestic supplies in rural areas, may be easily contaminated.

1. Shallow Water-Table Aquifer System

The shallow aquifer in South Carolina is composed of surficial sediments in the Coastal Plain and Sand Hills; and fluvial sediments and saprolite in the Piedmont and

Blue Ridge Physiographic Provinces (Figure 4). The

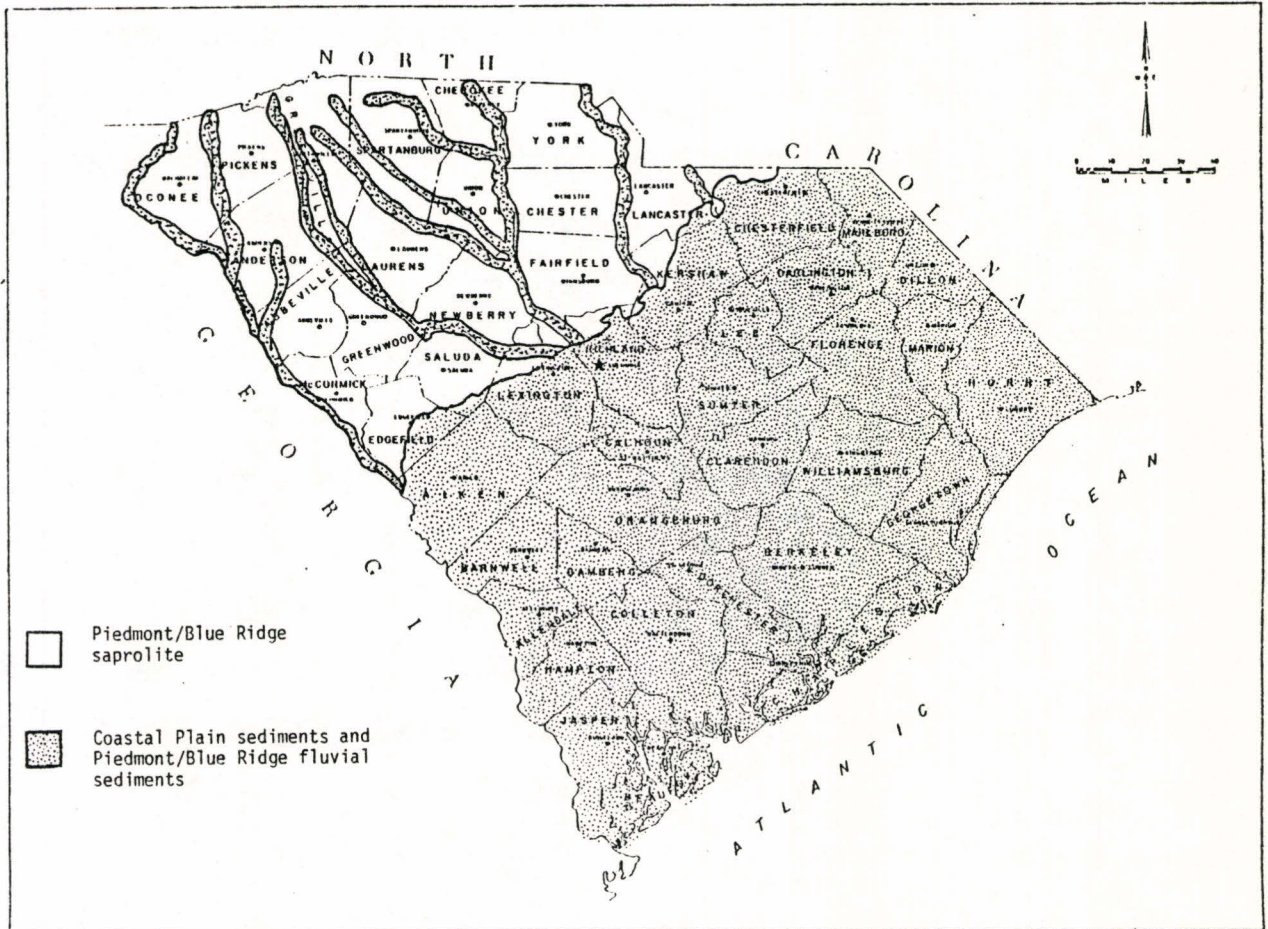


Figure 4. Map showing location of the Shallow-Water-Table Aquifer System. (From Padgett and Hardee, 1982).

recent age sediments of the Coastal Plain, which comprise the shallow aquifers in the lower half of the State, are composed primarily of unconfined sands and gravels interbedded with layers of clay. The thickness of the shallow aquifer in the Coastal Plain generally ranges from 0 to 80 feet, depending upon the physiographic province and depth to any underlying confining zones (clay strata).

The shallow aquifer in the Piedmont and Blue Ridge Provinces is composed of weathered igneous and metamorphic rocks overlain, usually within the flood plain valleys, by gravels, sands, and clays of more recent age. The shallow aquifer system in the Piedmont/Blue Ridge generally ranges from 0 to 100 feet thick. Recharge to the shallow water-table aquifer system occurs at the ground surface by infiltration into surficial soils.

The major aquifers of South Carolina are almost everywhere overlain by the shallow aquifer system, consisting of a thin veneer of shallow sediments which mask the near-surface occurrence (subcrop) of the major aquifer systems. The hydrologic relationship between the shallow aquifer and the underlying aquifers is not always known, but because of the nature and thinness of the shallow sediments, it is probable that this aquifer serves as a source of recharge for the underlying major aquifers.

The shallow aquifer is an easily developed source of water but because of the varying, sometimes low yields, seasonal fluctuations in water levels, and susceptibility to contamination, this aquifer system is not commonly utilized as a source of public drinking water except along the immediate coast. Individual wells developed in the shallow aquifer in the Coastal Plain generally range in yield from 3 to 50 gpm, with the higher yields from multiple sand-point well systems. In the Piedmont/Blue Ridge, the unconfined ground water tends to accumulate in

the saprolite overlying the bedrock. Most of the hand dug and bored wells are constructed in this zone. Shallow wells in the Piedmont/Blue Ridge generally yield 3 to 20 gpm.

2. Igneous and Metamorphic Bedrock Aquifer System

The Igneous and Metamorphic Bedrock Aquifer System extends over both the Blue Ridge and the Piedmont physiographic provinces. The Igneous and Metamorphic Bedrock Aquifer System is a major source of potable water for rural areas in the northern section of the state (Figure 5). There are, at present, about 1400 public water-supply wells developed in the bedrock aquifer. In the rural areas of the Piedmont/Blue Ridge there is a complete dependence on the aquifer for domestic use.

Yields as high as 400 gallons per minute (gpm) have been reported for single wells, with average yields of 15 to 30 gpm per well. Recharge to the Igneous and Metamorphic Bedrock Aquifer System occurs from precipitation, directly, in outcrop areas, and indirectly from inflow from overlying saprolite and alluvium.

3. Tertiary Sand Aquifer System

The Tertiary Sand Aquifer System extends over parts of the Upper Coastal Plain physiographic province (Figure 3).

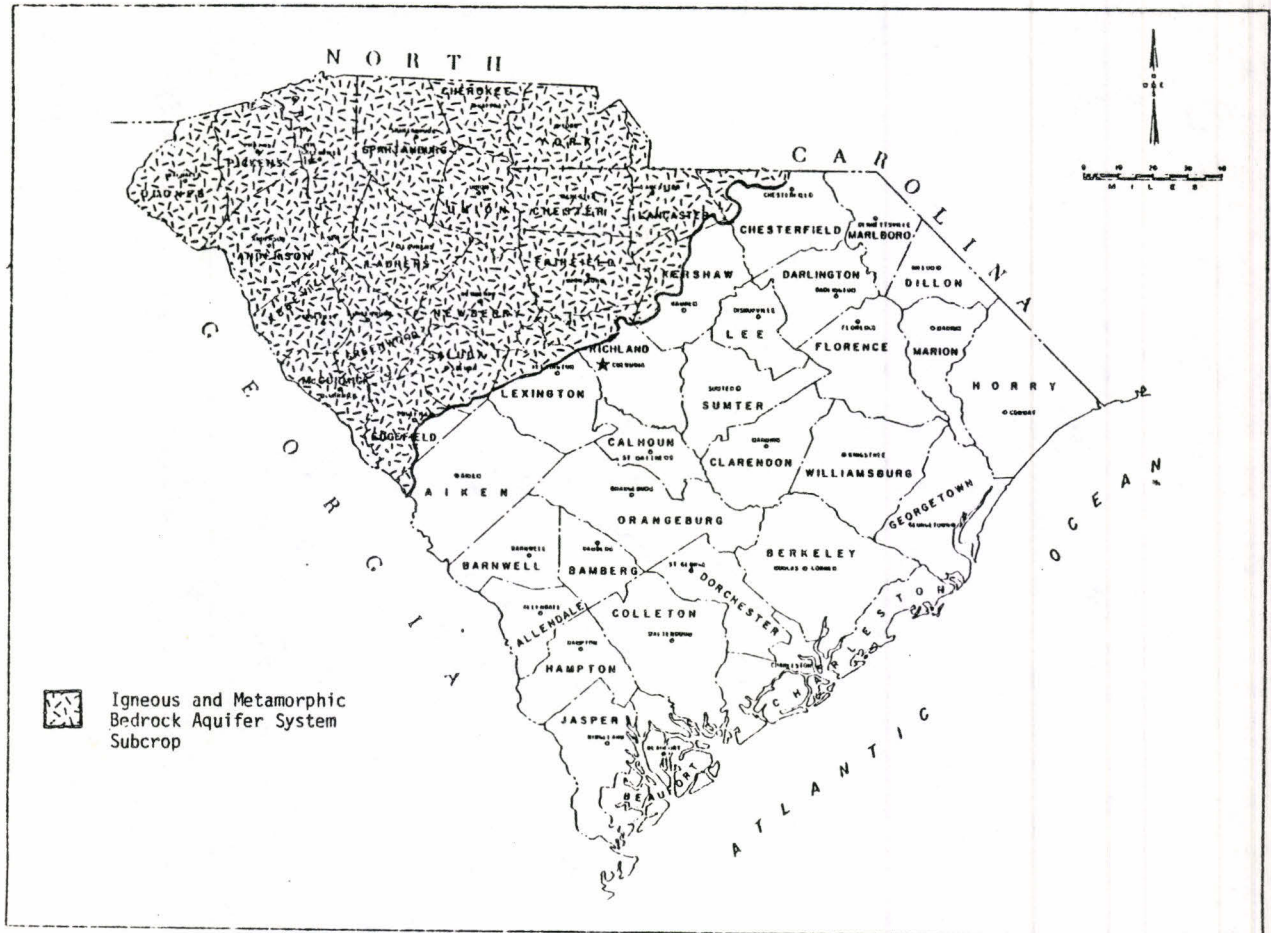


Figure 5. Map showing location of Igneous and Metamorphic Bedrock Aquifer System Subcrop. (From Padgett and Hardee, 1982)

The Tertiary Sand Aquifer System is composed of sands, gravels, clays, marls, and unconsolidated limestones of varying depositional environments. Two groups of formations comprise this aquifer system--the Black Mingo Group and the Orangeburg Group (Figure 6).

Deposits of the Black Mingo Group, within the subcrop areas in conjunction with the overlying sediments, are sometimes believed to be part of the Shallow Water-Table Aquifer. Yields of 300 to 500 gpm per well

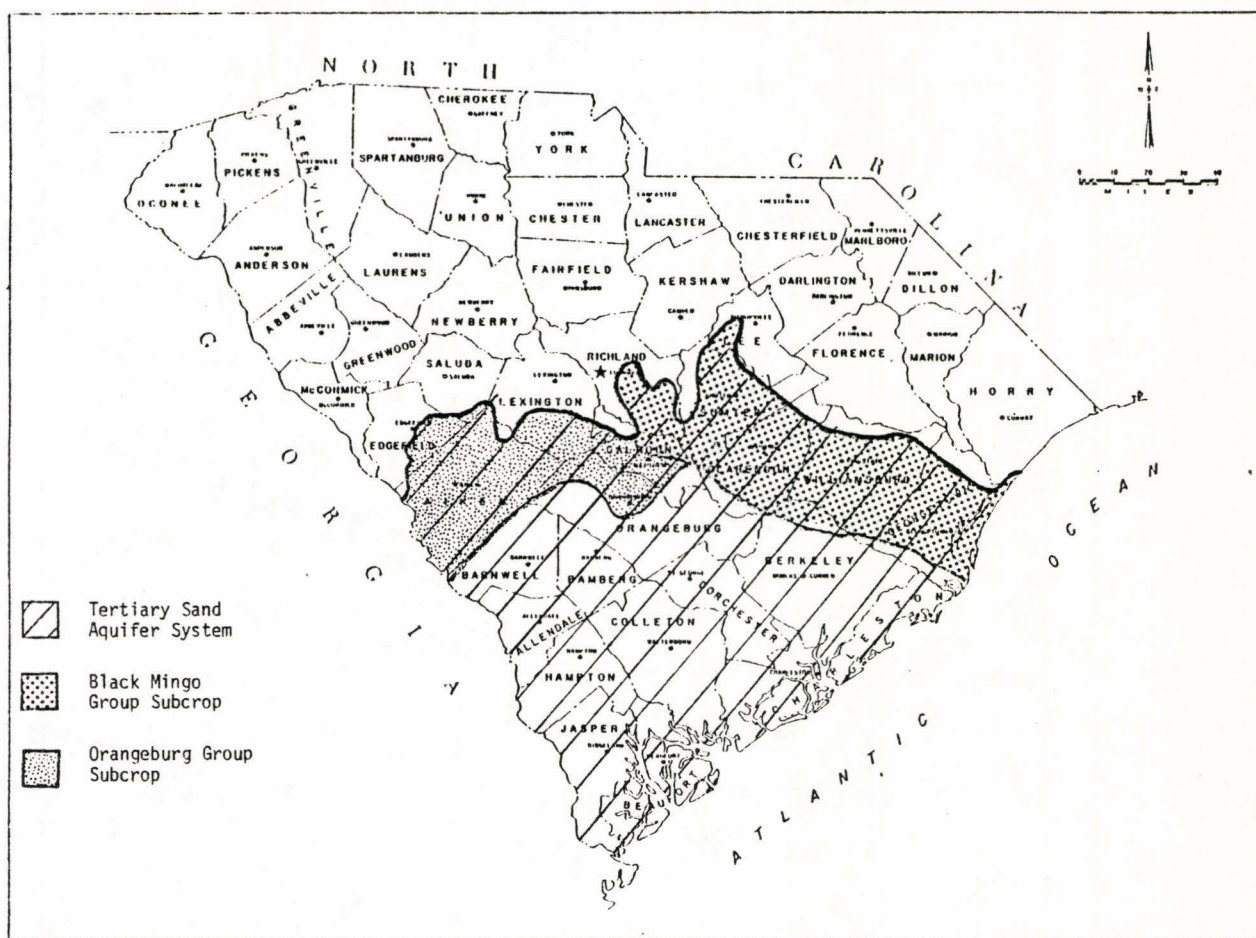


Figure 6. Map showing location of the Tertiary Sand Aquifer System showing area of subcrop for the Black Mingo Group and Orangeburg Group (From Padgett and Hardee, 1982)

have been obtained from the Tertiary Sand Aquifer System for large irrigation systems in Sumter, Calhoun and eastern Richland counties.

In subcrop areas, the Orangeburg Group is hydraulically connected to the overlying sediments and is considered to be part of the Shallow Water-Table Aquifer. Yields of up to 350 gpm per well have been reported for the aquifers of the Orangeburg Group.

Both the Black Mingo and Orangeburg Groups are important sources of ground water for domestic, indus-

trial, agricultural, and public water supply systems. The Black Mingo is the major artesian aquifer of the Tertiary Sand system. Recharge to the Tertiary Sands occurs in the subcrop areas (Figure 6). The water quality of the aquifers is variable, but normally good.

4. Tertiary Limestone Aquifer System

The Tertiary Limestone Aquifer System is a series of limestones ranging in age from Eocene to Miocene (Figure 7). The formations included in this series are, in ascending order, the Santee-Ocala Limestone, the Cooper, and the Hawthorn. The Santee-Ocala and Cooper Formations comprise the principal artesian aquifer, a primary source of ground water in the southwestern Lower Coastal Plain of South Carolina.

Portions of the Hawthorn and Cooper Formations, e.g. "Cooper Marl", are excellent confining beds (aquicludes) between the shallow water-table aquifer and the underlying principal artesian aquifer. Presently, little is known about the hydraulic properties and continuity of these confining beds. However, it is known that if the beds are breached and/or not extensive, the principal artesian aquifer is being directly recharged by the shallow aquifer (Hardee, 1982).

In the Burton community, Beaufort County, significant recharge is taking place in what is referred to as the "Burton High." The name initially referred to the

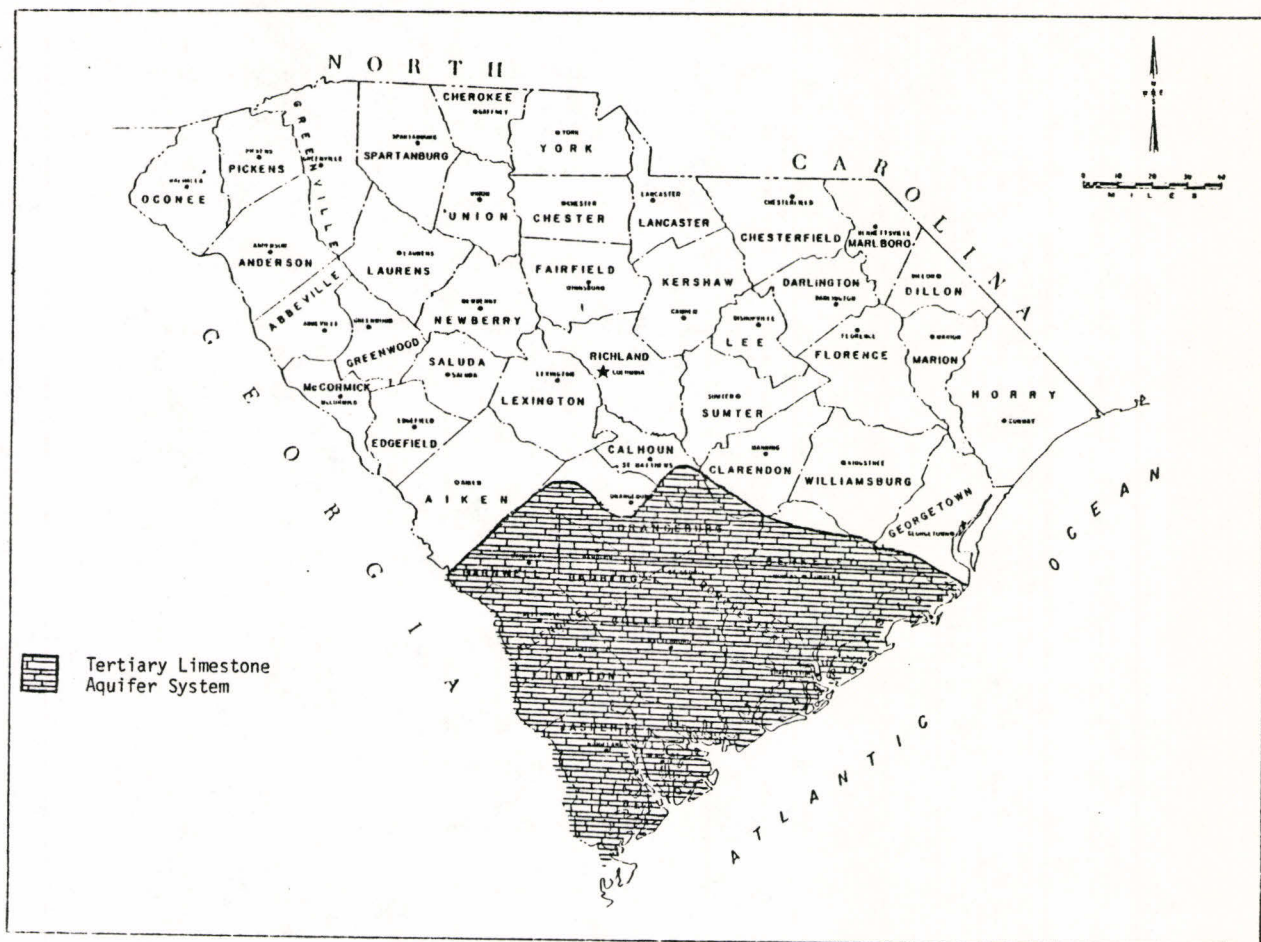


Figure 7. Map showing location of the Tertiary Limestone Aquifer System subcrop. (From Padgett and Hardee, 1982)

near-surface occurrence of the principal artesian aquifer near Burton, South Carolina. Later, the existence of a potentiometric high in the limestone aquifer at the same location added more significance to the name by indicating the area to be a recharge zone to the principal artesian aquifer, i.e., the term "high" carries a stratigraphic and potentiometric connotation (Hardee, 1982).

The Santee-Ocala Limestone subcrops in southern Orangeburg, Berkeley, Dorchester, northeastern Charleston, northwestern Colleton, and southwestern Clarendon counties. The formation consists of a wedge of limestone which deepens and thickens toward the coast. Yields from the aquifer range from an average 80 to 120 gpm to as high as 3000 gpm per well in down-dip areas. The aquifer is utilized for domestic, industrial, irrigation and public water supply systems.

The Cooper Formation, Eocene in age, subcrops in Barnwell, Bamberg, northwest Orangeburg, northern Allendale, central Charleston, and northwestern Dorchester counties and portions of Berkeley County.

The lower limestone unit is considered part of the principal artesian aquifer with water quality similar to the Santee-Ocala Limestone. The Cooper is not used extensively as an aquifer except in Hampton, Beaufort and Jasper counties where the lower limestone unit yields moderate to large amounts of good-quality water.

Overlying the Cooper Formation is the Hawthorn Formation of Miocene age which subcrops in Allendale, Colleton, Dorchester, Hampton, Jasper, Beaufort and southwestern Charleston counties. The Hawthorn is capable of yielding 50 to 200 gpm of good quality water and is utilized for domestic, agricultural and light industrial purposes.

5. Black Creek/Peedee Aquifer System

The Upper Cretaceous sediments overlying the Midden-dorf Formation are, in ascending order, the Black Creek and Peedee Formations. Portions of these two formations are major aquifers in much of the Coastal Plain physiographic province of eastern South Carolina (Figure 8).

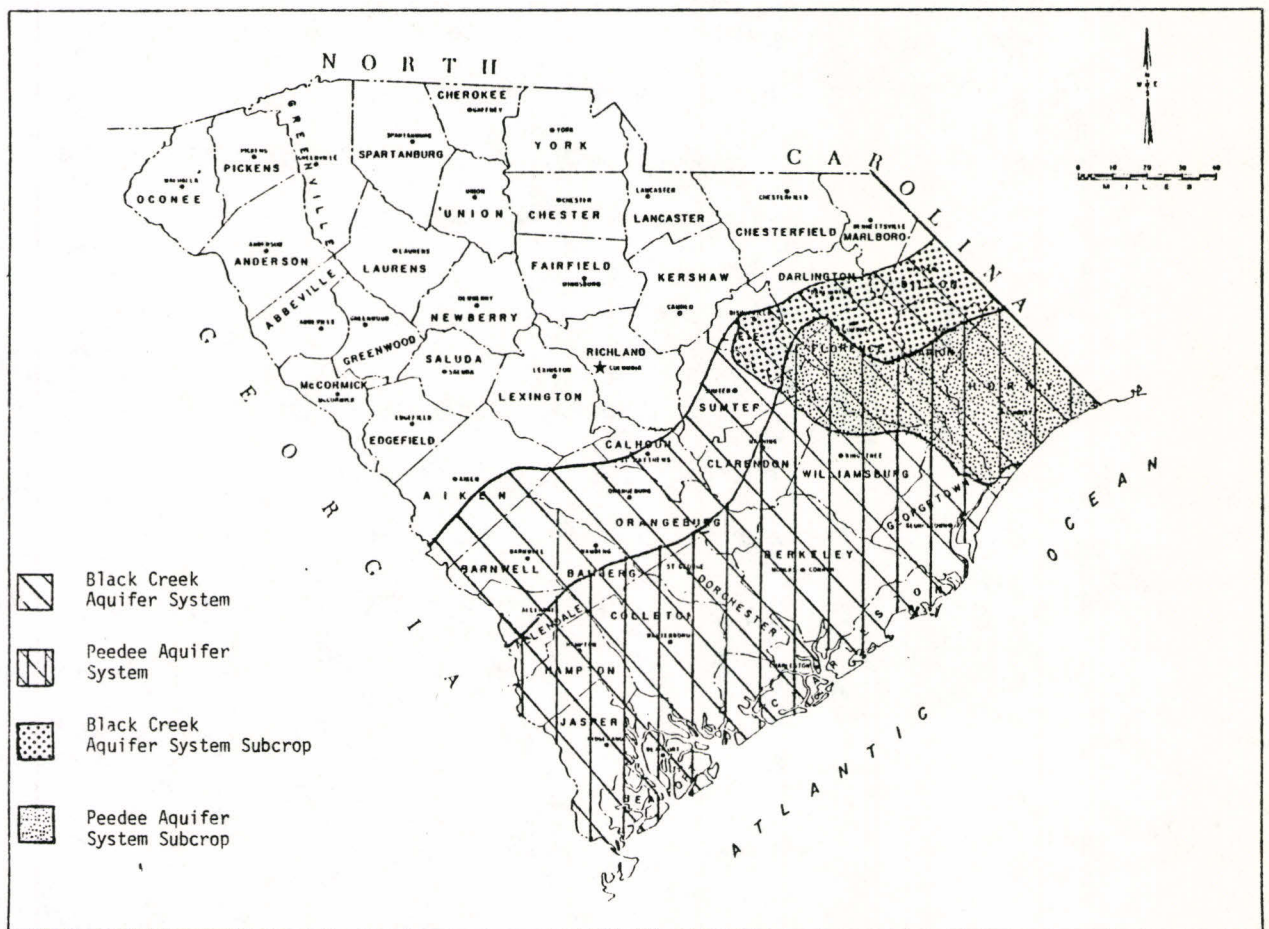


Figure 8. Map showing location of Black Creek/Peedee Aquifer System and areas of subcrop. (From Padgett and Hardee, 1982)

The Black Creek/Peedee is the major artesian aquifer system for the Grand Strand area (Horry and Georgetown). In much of eastern South Carolina, the aquifer system is utilized for residential, industrial and public water supply systems. Recharge to the aquifer system occurs primarily in Marion and Horry counties and in the Pee Dee River Basin area of Dillon, Florence, Darlington, southern Lee and western Sumter counties. Yields for the aquifer system range from an average of 20 to 250 gpm to as much as 1000 gpm. Yields of 500 gpm are common in Horry County where the Peedee subcrops.

6. Middendorf Aquifer System

The Upper Cretaceous Middendorf Formation (formerly referred to as the Tuscaloosa) rests unconformably on the igneous and metamorphic rocks of the crystalline basement. The Middendorf Formation subcrops in the northern portion of the Upper Coastal Plain in Chesterfield, Marlboro, Kershaw, northern Darlington, northern Lee, and the northern coastal plain portions of Richland and Lexington counties (Figure 9).

The formation consists mainly of fluvial, deltaic, and estuarine deposits of poorly sorted, cross-bedded micaceous sands and gravels interbedded with kaolinitic clays. The regressive/transgressive sequence of deposition of the Upper Cretaceous formations has resulted in an interfingering of the formations. This has resulted

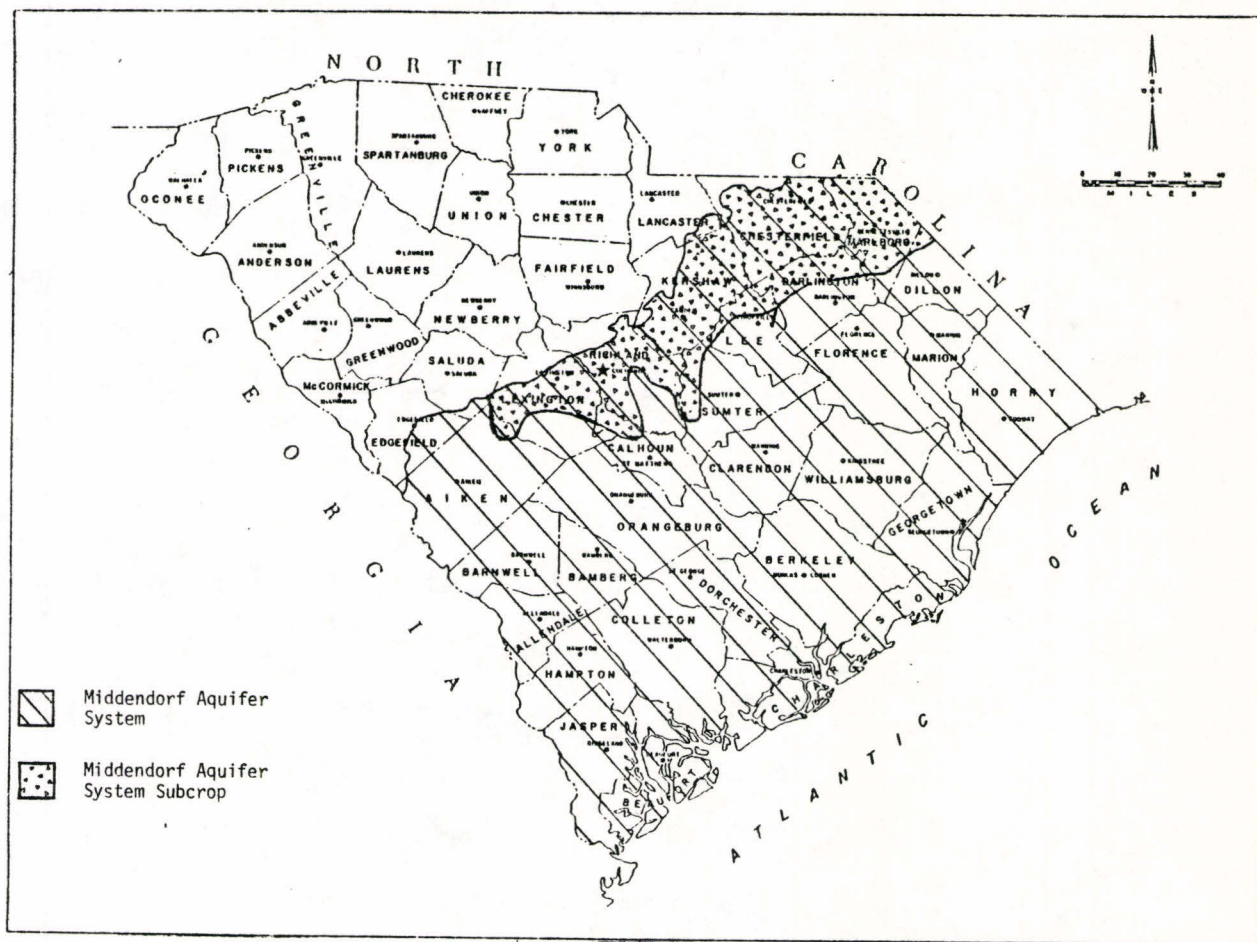


Figure 9. Map showing location of Middendorf Aquifer System and area of subcrop. (From Padgett and Hardee, 1982)

in a division of the Middendorf Formation into two distinct aquifers separated by clastic sediments of the Black Creek Formation. The two aquifer zones are referred to as the Upper and Lower Middendorf formations which make up the Middendorf Aquifer System (Padgett and Hardee, 1982).

The Middendorf Formation ranges from a feather edge along the fall line to a continuing thickness of six

hundred feet, becoming progressively deeper toward the Atlantic Ocean.

In the upper Coastal Plain physiographic province, large volumes of water rapidly infiltrate into the surficial water table aquifer which is hydraulically connected to, and therefore recharging, the Middendorf Aquifer System. Any contaminated water in the shallow aquifer can potentially mix with water in the underlying Middendorf aquifer.

The Middendorf Aquifer System is the major aquifer system in the Upper and Middle Coastal Plains of South Carolina, with yields in domestic wells ranging from 20 to 150 gpm and public water supply wells ranging from 500 to 2500 gpm. The overlying aquifer systems are utilized more extensively in the Lower Coastal Plain with the exception of Williamsburg and Clarendon counties where yields of up to 1200 gpm have been reported from wells in the Middendorf Aquifer System.

V. CITATIONS OF SIGNIFICANT SOURCES OF POTENTIAL GROUND-WATER CONTAMINATION

The purpose of this section is to briefly present in non-technical terms, a description of the activities of man which potentially threaten ground-water quality.

There can be a variety of potential ground-water contamination sources which have been thoroughly discussed in the literature (Lehr, et. al., 1976; S.C.D.H.E.C., 1978, 1980; Council on Environmental Quality, 1978).

A. Contamination Sources on the Land Surface

Many ground-water-quality problems are caused by the dumping, spreading, or storage of soluble substances on the land surface. The following, although not all-inclusive, lists the major causes of ground-water pollution which originate on the land surface and present a significant threat to ground-water quality in South Carolina.

1. Disposal of Wastes on the Land

One of the major ground-water-contamination problems nationwide, the spreading of wastes on the land, is also a major threat to ground water in South Carolina. Examples of such wastes include sewage and sewage treatment sludges, industrial wastewater and associated sludges, and manure, among many others. Disposal methods may be highly variable, both in method and scale. Solids may be disposed of in individual mounds or spread over the land. Liquids can be sprayed over large areas, or simply dumped and allowed to seep into the ground. If the waste material contains soluble components, they will be leached by infiltrating precipitation and carried downward. Whether ground water becomes contaminated as a result is a function of a set of complex variables including the volume and concentration of the waste, the depth to ground water, the permeability and renovative capacity of the soils, how long the leaching continues, and the persistence of the contaminants.

Given the volume and toxicity of the wastes which will need to be disposed of in some manner, their disposal on the land collectively must be considered one of the most significant sources of potential ground-water contamination in South Carolina.

2. Accidental Spills

Careless and unmonitored handling and transportation of hazardous materials is a serious potential source of ground-water contamination. The areal extent of problems associated with spills is typically not as great as some other sources, however, toxicity can be extremely high. A wide variety of toxic materials are transported throughout the State and major spills are not uncommon. The most spectacular and publicized spills are highway and railroad accidents which may involve many thousands of gallons of hazardous liquids.

The importance of spills as a potential source of ground-water contamination is compounded by some emergency-response procedures which accelerate and add to infiltration. Immediately following an accident, it is sometimes necessary to flush the spill area with water in order to wash the spilled material from the highway. Foam is sometimes used to minimize the potential for fires. When runoff occurs, the fluids are typically impounded by dikes in order to protect nearby streams. All of these necessary actions add to the amount of

contaminants which infiltrate into the subsurface. Once in the subsurface, such pollutants are difficult to recover if the contaminated soils are not immediately removed, as is the normal procedure. If the spilled material contains soluble components, they will be leached by infiltrating precipitation and carried downward. Whether ground water becomes contaminated as a result is a function of the previously discussed variables (nature of the spilled material, depth to ground water, permeability and renovative capacity of the soils, how long the leaching is allowed to continue, and the degradability of the contaminants). Under unfavorable conditions, significant, essentially permanent ground-water contamination can be the result.

3. Fertilizers and Pesticides

Both fertilizers and pesticides are extensively used in South Carolina and the use trend appears to be upward. Many of these substances are highly toxic to human beings and a wide variety are persistent and very soluble in water. If over-applied to croplands and residential areas or carelessly handled, fertilizers and pesticides can severely contaminate ground water over extensive areas, as has been the case in many areas of the Midwest and on Long Island, New York. There is a definite potential in South Carolina for regional contamination of ground water by fertilizers and pesticides if care is not

exercised in handling, in siting, and in controlling application.

An associated potential contamination source is the back-siphoning of fertilizers and pesticides into irrigation wells.

4. Animal Feedlots

Animal feedlots cover relatively small areas but tremendous volumes of nitrogen-bearing animal wastes are created. Improperly located, concentrated animal-feeding operations have a strong potential to contaminate ground water with nitrate. The consumption of nitrate-rich water leads to a serious disease in infants commonly known as "blue babies", or methemoglobinemia.

The processes whereby accumulated animal wastes leach nitrate follow the same pattern as previously discussed with the potential for ground-water contamination dependent on the depth to ground water, permeability and renovative capacity of the soils and how long the leaching continues. Although not of the same magnitude or toxicity as other wastes, animal wastes from concentrated feeding operations can significantly contaminate ground water on a local basis.

5. Other Less Significant Sources Which Occur on the Land Surface

- a. Stockpiles - Not uncommonly, hundreds and thousands of tons of raw materials and wastes are simply piled

on the land surface awaiting use or disposal. The soluble components contained in such stockpiles can easily be leached by infiltrating precipitation and carried downward into ground water. As long as the stockpiling is temporary, the impact is usually minimal, but when long-term stockpiling is practiced, ground-water contamination is common.

- b. Infiltration of polluted surface water - Occasionally, polluted surface water can contaminate ground water in the area near the polluted stream. The most common example is induced infiltration of stream water caused by the pumping of water-supply wells along the stream bank. The more significant cases of ground-water contamination result when the stream, which is losing water to the ground, is grossly polluted itself. Very rarely in South Carolina do streams lose water to the ground under natural conditions; therefore, this category is considered significant only in isolated cases in the immediate area of pumping (see page 43 regarding ground-water development).

B. Contamination Sources below Land Surface above the Water Table

Many different types of materials are stored or disposed of in the ground above the water table (ground water). Ground-water contamination can originate from these operations unless care is practiced. The following provides a brief

categorical description of some of the more important potential ground-water contamination sources which take place in the ground above the water table:

1. Landfills

Landfills generally are constructed by placing wastes in excavations and covering the waste material daily to prevent the infiltration of precipitation. The term "sanitary", applied to landfills used to dispose of domestic waste, indicates that garbage and other materials are not left exposed to produce odors, smoke, vermin, and insects. Industrial landfills, used to dispose of non-domestic, non-hazardous waste, are operated in a similar manner, depending on the nature of the waste. Hazardous-waste landfills normally are required to install liners, leachate-collection systems, and sophisticated monitoring systems, in hydrogeologically well-suited locations. Even though a landfill is covered, leachate may be generated by the infiltration of precipitation and surface runoff. Fortunately many substances are removed from the leachate as it migrates downward and filters through the unsaturated zone, but leachate may grossly pollute ground water and may even pollute streams if it discharges at the surface as springs and seeps (Figure 10).

There is a wide range of variables which dictate whether a particular landfill is a potential ground-

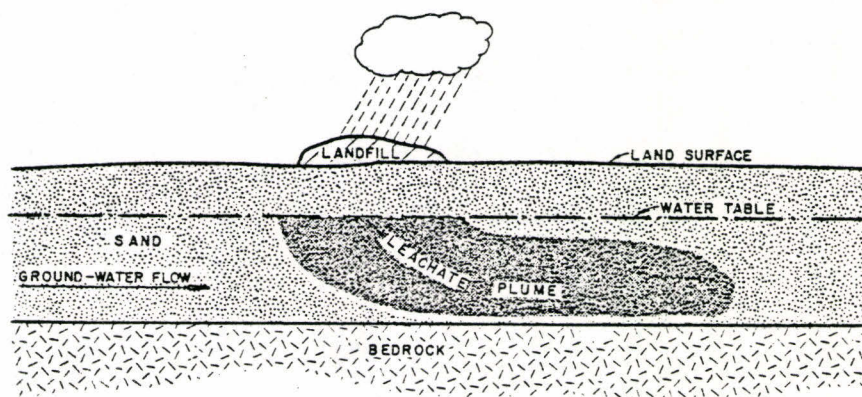


Figure 10. Generalized diagram showing ground-water contamination by landfill leachate. (From U.S.E.P.A., 1980, p. 56)

water-contamination source. These variables include the nature and amount of the landfilled wastes (solid vs. liquid, toxic vs. non-toxic, soluble vs. insoluble, etc.), how the landfill is designed and operated to minimize leachate generation, the depth to the water table, the permeability and renovative capacity of the soils, and the persistence of the contaminants in the leachate.

Serious ground-water contamination is likely when any one or a combination of these conditions is unsatisfactory and not taken into account. Considering the tremendous volume of waste which has been and will need to be landfilled in South Carolina, landfills must be considered one of the major sources of potential ground-water contamination.

2. Surface Impoundments

Surface impoundments include a wide variety of facilities which more or less contain liquids for various reasons. The more common surface impoundments are relatively shallow excavations that range in surface area from a few square feet to many acres. Such ponds or lagoons may be used to store and/or treat domestic sewage, industrial process wastes, and many other wastes which may be highly concentrated and which may contain a wide variety of toxic chemicals.

Surface impoundments are commonly considered to be liquid-tight but the vast majority leak large quantities of fluids. They have been euphemistically called "evaporation" ponds, appropriate in arid regions, since the early days of pollution control. However, in South Carolina, precipitation rates generally exceed evaporation rates and there is negligible net evaporation from surface impoundments to the atmosphere. Whenever the overflow from a pond or lagoon is significantly less in volume than the inflow, the difference is usually leaking into the subsurface. Depending on the nature of the "contained" waste or raw material, the rate of leakage, the hydrogeological conditions, and the length of time the leakage is allowed to continue, ground water can be grossly polluted over large areas.

The South Carolina Surface Impoundment Assessment Report (S.C.D.H.E.C., 1980) inventoried 2259 waste impoundments, 99 percent of which were unlined, and only 2 percent of which had ground-water monitoring. Considering the abundance of surface impoundments, the types of wastes or raw materials contained therein, and the fact that many, if not most, leak substantially, the category of surface impoundments must be classified as a major potential threat to ground-water quality.

3. Septic Tanks

Almost everyone is familiar with the septic tank. It is a buried tank which removes the solids from and anaerobically treats household sewage prior to subsurface disposal in the tile field. Individually of little significance, these devices are important in the aggregate because they are so abundant and occur in every area not served by municipal or privately-owned sewage treatment systems. Septic tanks do not adequately treat non-biodegradable industrial wastes even though they have commonly been used for this purpose.

The most common ground-water contamination problems resulting from septic tanks have been caused by nitrogen overloading in areas where septic tanks are of high density and/or where geological conditions are not favorable for ground-water-quality protection. The standard

term "failing septic tank" has only been applied to the overflowing, obviously odorous surface failure caused by tight soils, shallow water table, and tile-field clogging. The term "failing septic tank" should also be applied when effluent contaminates ground water (Figure 11).

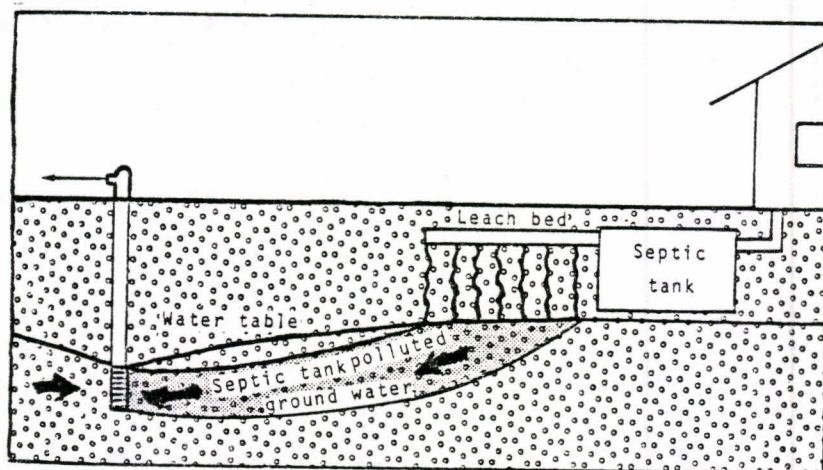


Figure 11. Schematic diagram showing ground-water contamination from a septic tank. (From U.S.E.P.A., 1976, p. 67)

In addition to nitrogen, there is growing concern about the impact of septic tanks caused by toxic organics and viruses. A wide variety of household chemicals are dangerous and not effectively degraded by septic-tank treatment processes. Viruses, hundreds of times smaller and more persistent than bacteria, may travel great distances in the subsurface and contaminate ground water over large areas.

4. Leakage from Underground Tanks and Pipelines

Probably the most complained about ground-water contaminant in South Carolina is gasoline. A slow, unsuspected leak over a long period may be most harmful, since extensive damage may occur prior to its detection. In these instances, cleanup may be more difficult and expensive than for a sudden spill, which is usually detected quickly. Petroleum leaking into soil will tend to flow downward, with some lateral spreading. The rate of product movement in the soil will depend on product viscosity, soil properties, and the rate at which the product has been lost. For example, light products, such as gasoline, will penetrate rapidly, while heavy oils will move more slowly. If the near-surface soil has a high clay content and very low permeability, the product may penetrate very little or not at all. However, a porous, sandy soil may absorb the product quickly. Petroleum products, being less dense than and immiscible in water, accumulate in the soil near the ground-water surface (water table) and leak into basements, storm drains, sewers, utility conduits, springs, wells, and streams. This accumulation results in the strong potential for noxious fumes, explosions, and fires. When it is present in ground water in even very small amounts, it is obvious to the well owner that an alternate source of water must be found. In higher concentrations gasoline

and other petroleum products have caused severe hazardous pollution problems (Figure 12).

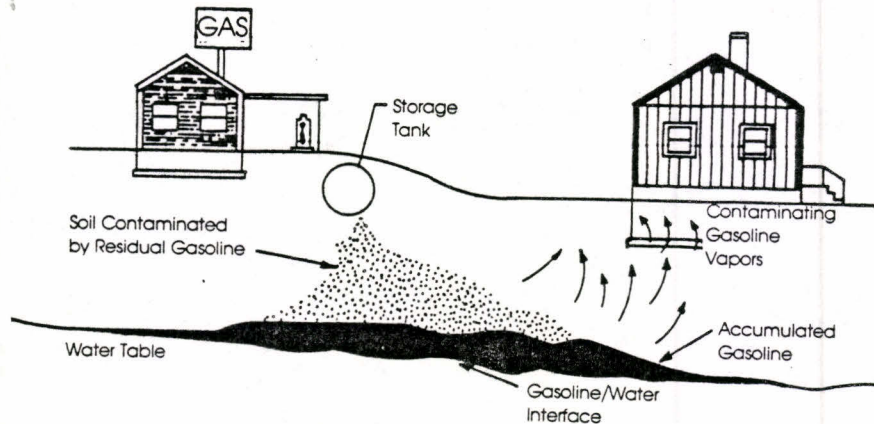


Figure 12. Schematic diagram illustrating leaking underground storage tanks. (From Yaniga, p. 41)

The significance of leakage from underground tanks and pipelines is expected to increase. A great number of service stations with buried storage tanks were constructed in the post-war period and the tanks have already exceeded their design life. South Carolina soils are chemically corrosive and the design life-expectancy for a buried metal tank is only about fifteen to twenty years. Unless measures are taken to keep an accurate product inventory, to test buried tanks for leaks on a periodic basis and to properly install new tanks, the contamination of ground water is expected to continue at, and probably exceed, the present rate.

Leaky buried tanks and pipes in industrial process areas are also a significant source of ground-water contamination which has the potential to introduce large volumes of toxic materials into ground water, depending on the previously discussed variables.

5. Artificial Recharge

Artificial recharge includes a variety of techniques used to increase the amount of water infiltrating to ground water. It consists of spreading the water over the land or placing it in pits, ponds, or wells from which the water will seep into the ground. As water demands continue to increase, there is no doubt that artificial recharge will become increasingly popular as a means of providing a sustained yield to water supplies in South Carolina which depend on overdrawn aquifers.

Waters used for artificial recharge can consist of storm runoff, irrigation return flows, stream water, cooling water, and treated sewage effluent, among others. Obviously, the quality of water artificially recharged can have a major effect on the water in the ground, and if not properly pretreated and controlled, can become a significant contamination source.

6. Other Less Significant Sources Which Occur below Land Surface above the Water Table

- a. Sumps and dry wells - Sumps and dry wells are small-scale, shallow structures which are commonly used to collect runoff, spillage, and other fugitive liquids in small quantities. Many are not water-tight and some are designed to leak (see Injection Wells), therefore, they may transmit to ground water whatever pollutants are flushed into the sump or well. Not considered a large-scale ground-water-contamination source, sumps and dry wells can be significant on a local basis.
- b. Graveyards - Leachate from buried animal bodies can potentially contaminate ground water, although cases are not well documented. Individually of little significance, gravesites en masse present a greater threat. Of particular concern would be the mass burial of large numbers of animals such as cattle, chickens, or swine in a small area where infiltrating precipitation could create leachate for extended periods.

C. Contamination Sources below the Water Table

The previously discussed activities, which are conducted at or near the land surface, have all shared the condition that there is a zone of unsaturated soil above the ground water. The hydrologic and geochemical characteristics of the

unsaturated zone are critical because they dictate the ground-water-contamination potential at any particular location. The unsaturated zone has often been erroneously assumed to be a complete safeguard to the downward movement of contaminants. Even though the ground-water protection afforded by the unsaturated zone is finite and sometimes inadequate, there is usually some buffer, or safeguard, separating man's activities from ground water.

Therefore, some of the most significant potential ground-water-quality problems can be expected to originate below the water table. The threat from these activities is magnified by the fact that the zone of aerated soil above the water table does not come into play as a filtering and treatment mechanism. Without the buffer provided by the unsaturated zone, ground water is extremely vulnerable to permanent, almost instant contamination on a regional basis. The following categories of activity which occur below the water table are briefly described regarding their significance as potential sources of ground-water contamination:

1. Injection Wells

For decades, man has used wells to get rid of his wastes and the practice has a wide range of complexity, from the deep injection of large volumes of toxic liquids to the shallow injection of non-polluted cooling water. A considerable number of deep-well waste-disposal projects exist across the country, primarily at indus-

trial sites. Injection wells have been allowed in other states when more conventional waste-disposal methods were not suitable and where hydrogeological conditions were appropriate (very deep, saline injection formations). In South Carolina, waste disposal by well injection has not been permitted.

The significance of the potential threat of waste injection to ground-water quality is anticipated to greatly increase for several reasons. The primary motivations for industry and developers to pursue injection are the well-established regulatory programs which place stringent limitations on the other more conventional methods of waste disposal. Public pressure against such practices as the landfilling of hazardous wastes will also add to the inclination toward waste injection into the subsurface.

There is also a remote possibility that the potential threat to ground-water quality from oil and/or natural-gas production, with associated reinjection of brines and secondary-recovery injection methods, will someday become a reality in South Carolina.

Ground-water-source heat pumps are increasingly becoming popular, and in many cases, reinjection of the thermally altered water is chosen as the disposal method.

All of these previously mentioned injection practices clearly have a significant potential to permanently contaminate ground water at great depth on a regional scale. While not considered a serious problem in South

Carolina at the present, injection wells will certainly need to be carefully considered as a source of significant potential ground-water-quality problems.

2. Ground-Water Development (Overpumping)

In certain areas the pumping of ground water can induce significant water-quality problems. Such problems can result because the lowered water levels in the vicinity of pumping necessarily change the pattern of natural ground-water flow. The aquifer which is pumped usually contains the highest quality ground water available in the area and if any inferior quality ground or surface water is within the area of influence (cone of depression) it will have a tendency to move toward the pumping well or pumping center.

The inferior quality water can be of natural origin including seawater, mineralized ground-water (connate saltwater), or ground water which naturally does not meet one or more standards. In these situations the lowering of the hydrostatic head in the high-quality aquifer leads to migration of more highly mineralized water toward the well site. Undeveloped coastal aquifers commonly have a water level above sea level, the hydraulic gradient slopes towards the sea, and fresh water discharges from the aquifer through springs and seeps on the ocean floor. Extensive pumping lowers the fresh-water potentiometric surface permitting sea water to migrate inland toward the pumping center (Figure 13). A similar predicament can

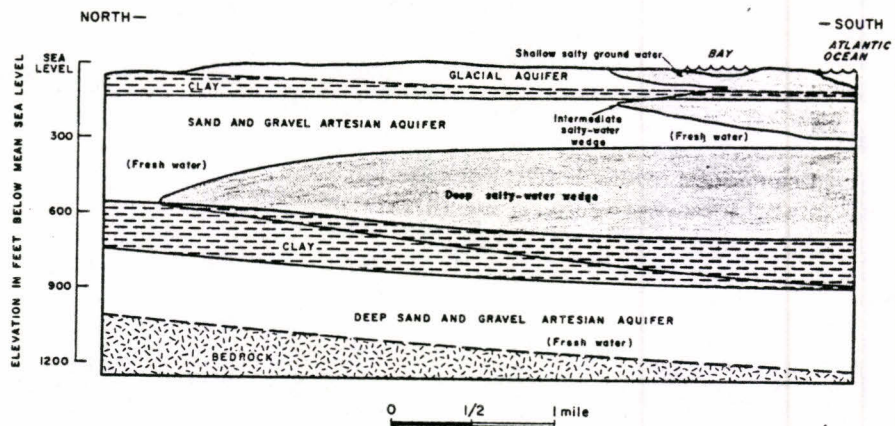


Figure 13. Generalized cross-section of a coastal area showing salt-water intrusion caused by overpumping. (From Wilson, 1981, p. 50)

occur in inland areas where mineralized or naturally inferior water is induced to flow upward, downward, or laterally into the high-quality aquifer due to the decreased head (pressure) in the vicinity of pumping.

Ground water, contaminated by man's activities, and polluted streams (see page 31 regarding infiltration of polluted surface water) can also contaminate aquifers in like manner but not on the same large, regional scale as associated with regional water-level decline in deep coastal aquifers.

Regardless of whether the overpumped aquifer is contaminated by natural or man-made contaminants, the change in water quality is essentially permanent and little can be done except to find an alternate source of water or increase treatment, both of which are expensive.

Ground-water development, although not considered a major ground-water-contamination source in South Carolina at the present, has a significant potential to threaten large areas of the better aquifers as the demand for ground water goes up and water levels continue to decline.

3. Water Supply Wells

Improperly constructed water-supply wells are a significant potential source of ground-water contamination below the water table. If a well casing is not grouted (cement sealed in a watertight manner) polluted surface runoff and polluted shallow ground water have a potential to flow along the side of the well casing into the aquifer. Additionally, large-diameter dug wells are difficult to protect and they are notorious for allowing pollution of shallow ground water from contaminants which flow into the well from the land surface. Deep wells which pass through zones of inferior quality ground water frequently are not grouted between the different aquifers and cross-contamination through the space outside the casing (annulus) may occur. For multiple-screened wells, there is an additional need to place grout collars between screens, to avoid leakage from one aquifer to another when the well is abandoned.

Another potential source of ground-water contamination associated with water-supply wells is the use of

polluted drilling fluids. However, the effects are usually local and diminishing as the well is pumped, normally removing the contaminants from the aquifer after a time. The poor-quality water produced from the well is the more serious problem.

An associated significant potential cause of groundwater contamination is the open hole into the subsurface frequently left unprotected when even a properly constructed well or test hole is abandoned. The open casing or hole, which remains after abandonment, can allow polluted surface water to drain directly into groundwater, and it can potentially receive highly toxic wastes, both accidentally and intentionally. A common example in South Carolina is the filling of abandoned dug wells with trash, including paint cans, pesticide bags, dead animals, etc. Of course, the deeper the abandoned well, the greater the significance of the potential contamination. There are probably thousands of abandoned wells and test holes in the State.

Similar to the introduction of contaminants from the surface into abandoned wells and test holes is the subsurface migration of mineralized ground waters through abandoned wells. In many cases the well which is abandoned has many screens (sections along the casing which are slotted to allow entry of water), which are set in the various sand layers (strata) in the aquifer(s). It is common for the head or hydrostatic pressure in these

sands to vary so that when the well is not being pumped, as after abandonment, there is transfer of water from screens in relatively high-head strata to screens in strata of lower head. Depending on head differential and permeability of the aquifer, this transfer of water can be of significant volume. Such a situation may not contaminate ground water if all the ground water in the various screened zones meets standards. However, especially in coastal areas, there can be great differences in water quality in the various parts of the aquifer. Because most wells in a given area are preferentially screened in the better-quality water, and the subsequent pumping has increased the head differential, any abandoned wells which are screened in both the good and bad water-quality zones will increasingly contaminate the better parts of the aquifer, as the head differential increases with pumping from other wells in the region.

The number of abandoned wells in South Carolina is not, and can not be, known. However, abandoned wells must be considered significant since the impact is instant and permanent, and, in the case of deep, multiple-screened wells, the impact is on heavily-utilized, major aquifers.

4. Underground Storage

The storage of raw materials (such as liquified natural gas) and wastes (such as high-level radioactive

wastes) in deep excavations is attractive from both economic and technical points of view. However, the geology and hydrology of the underground storage areas must be thoroughly understood in order to ensure that the materials do not leak from the reservoir and pollute adjacent ground water. It is anticipated that there will be a strong inclination toward the deep burial of the ever-increasing volumes of high-level radioactive wastes created by nuclear power generation. Because of the hazardous nature of such waste and the fact that South Carolina is a nuclear-waste acceptor, it is clear that underground storage is a significant potential threat to ground-water quality.

D. Relative Significance of the Activities Potentially Contaminating Ground Water

The activities cited have been included because any ground-water contamination is significant in its permanence. The assignment of relative significance to the previously discussed categories of potential causes of ground-water contamination is a complex, subjective matter. There are wide ranges of variation in several factors pertaining to each category. The factors include:

1. The volume of ground water contaminated
2. The toxicity of the contaminants
3. The irritation created by nuisance-type contaminants i.e., the number of complaints

4. The actual and potential frequency of occurrence
5. The duration of the contamination, and
6. The present level of regulatory control.

With this concept in mind, it is obvious that difficulty is encountered in attempting to equitably prioritize the wide range of activities previously discussed. For instance, a small spill of toxic chemicals into a water-table aquifer near shallow wells is a local problem but it could be considered more significant, if people die, than a regional non-health related problem such as salt-water intrusion. In like manner, a small injection well into a deep, high-quality aquifer may be considered more significant than a large waste-disposal operation where the contamination plume is managed and discharges to a nearby stream. Even within a particular category there is such a wide variation that comparisons with other categories are complicated.

Therefore, a very simple breakdown is provided, subjectively separating the more significant from the less significant and recognizing that there is considerable room for debate. The more serious potential threats to ground-water quality are considered to be: surface impoundments; landfills; underground tanks and pipelines; land disposal of wastes; and accidental spills.

VI. DOCUMENTATION OF THE CURRENT STATUS OF GROUND-WATER CONTAMINATION

The quality of ground water in South Carolina is predominantly excellent, with the exception of numerous local incidents where ground water has been contaminated by man. Table 1 has been com-

piled to provide the reader with a brief summary of the ground-water-quality problems which have been documented by chemical analysis of ground water. Because of the concern for public health and the permanent nature of ground-water contamination, a conservative approach has been taken. For the purposes of this report, ground water has been considered contaminated when any contaminant concentration in any well exceeds either the primary drinking-water standard or, in the case of organic compounds, established background water quality, i.e., the criterion has been applied to the worst case rather than to the average over the area or through time. In many of the situations cited in Table 1, the source(s) of the contamination has been removed, either voluntarily or as a DHEC requirement, and ground-water quality may have significantly improved since the contamination was originally discovered.

The table is by no means all-inclusive; rather, it lists those situations which have been discovered since 1975 by one of several methods including public water-supply monitoring, self-monitoring at waste-disposal sites and complaints from well owners.

The contamination cases cited vary greatly in scale and severity, from simple, shallow, localized occurrences of non-toxics to large amounts of toxic ground water in recharge areas.

There is also a wide range of importance which can be placed on the individual cases cited, depending on the toxicity of the contaminants, the area contaminated, whether the contaminated ground water will recharge deeper aquifers (as opposed to local discharge to streams), and the number of people potentially affected. The level of significance placed on the tabulated individual problems and the list as a whole is a matter of perception.

It could be said that only an extremely small percentage of South Carolina ground water is contaminated and that the current status is completely acceptable. However, even the smallest, apparently least significant, case of ground-water contamination takes on extreme importance to the well owner who must replace his water well, usually at great expense. In addition, the possibility of health effects resulting from the consumption of unmonitored, untreated ground water significantly increases the collective concern for contamination and where this contaminated ground water will eventually migrate.

Some generalizations can be made about the current status of ground-water contamination in South Carolina:

- The geographic distribution of the 157 tabulated ground-water-quality problems is widespread (See Figure 14). There are apparent concentrations in the industrialized, population centers (Greenville-Spartanburg, Richland-Lexington, and Charleston) with additional frequency based on hydrogeology (Richland-Lexington, Charleston, Sumter, Beaufort, Horry, and Edgefield).
- Nearly all the contaminated ground water in South Carolina is shallow (less than 50 feet deep) although there are a few exceptions in recharge areas and where the contaminants were introduced at depths such as through abandoned wells.
- Many problems were brought to light by citizens' complaints about staining, taste, odor, and/or sickness due to drinking water from wells. Of the 90 water-supply

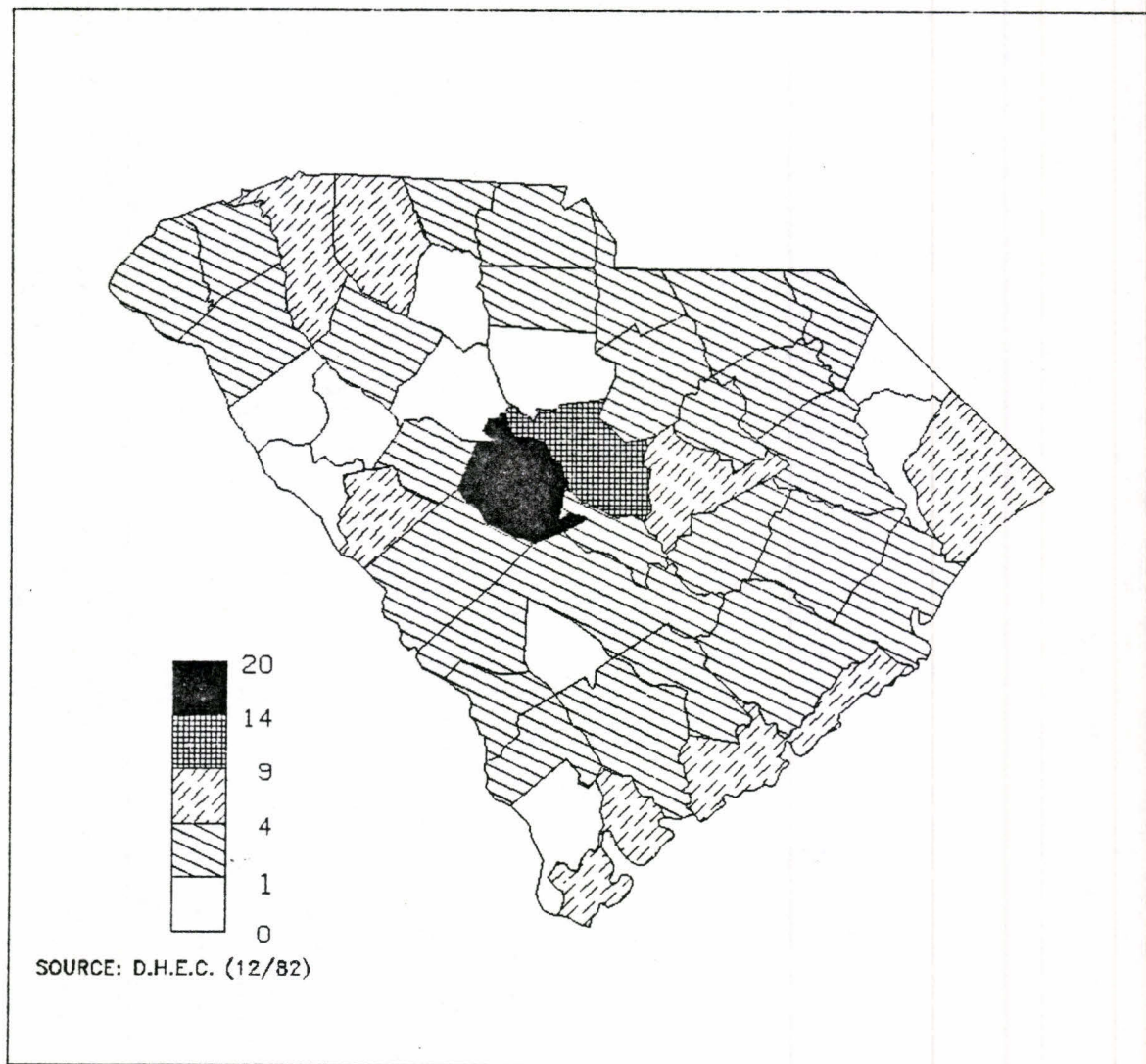


Figure 14. Density map of ground-water contamination cases in South Carolina.

wells found to be contaminated, about half were reported by private citizens due to one or more of the above stated reasons. Petroleum-based contamination, particularly gasoline, is very easily detected and is most

frequently reported. Approximately 30 percent of the total contamination cases involve petroleum products. Eighty percent of those were reported by the citizenry due to presence of a petroleum odor in a well, excavation, or spring.

- Of the 90 water-supply wells known to have been contaminated, about 55 percent were contaminated by sources other than the activities of the well owner, 30 percent by the well owners, and 15 percent by unknown sources.
- Most landfills and dumps of any size could contaminate ground water even though Table 1 cites only 26 incidents. The economic limitation of most counties has prevented their being able to install the monitoring programs necessary to evaluate ground-water quality at the operational, much less closed-out, landfill sites. The recently imposed requirement of DHEC that all active landfills install detection ground-water monitoring systems may add to the number of landfill citations in Table 1.

VII. RECOMMENDED STRATEGIES TO PROTECT THE STATE'S GROUND-WATER QUALITY

Ground-water-quality protection and the development of a strategy are complex matters requiring a skillful approach. As can be surmised from the previous sections, numerous activities of man have the potential to contaminate ground water to varying degrees. Some are simple, originating from more or less discrete sources such as spills or stockpiles. Others are not so simple, resulting from cumulative effects such as from many septic tanks or the

overpumping of ground water from many wells. And there are the interrelationships among many activities which are difficult to measure and understand.

Additional complications in the development of a ground-water-protection strategy arise from variations in geology, and, specifically, hydrogeology. A waste-disposal practice may be acceptable in one location, and completely unacceptable in another, depending on the site characteristics. Overpumping of ground water does not necessarily cause contamination; on the other hand, it can be disastrous, depending on the nature of the aquifers in the area. In the previous sections, some basic hydrogeologic variables have been discussed, e.g., depth to the water table, permeability of the unsaturated zone, the bio-chemical interrelationship between the soil and potential contaminants, etc..

The consideration of these factors is extremely important in the design of a ground-water-quality-management strategy. However, because of the nature of the ground-water resource and the intimate connection between land use and ground-water quality, one must assume that at least some activities of man will always contaminate ground water no matter what technological or regulatory safeguards are employed. It rarely will be economically or technologically feasible to restore a body of ground water to its pre-existing conditions within a reasonable time frame. Therefore, the aim of any protection strategy should be the protection of present and future uses of ground water, rather than attempting to achieve a zero discharge to the subsurface. Given the complexity of the circumstances leading to future ground-water-quality problems and

assuming that some contamination is unavoidable, it then becomes obvious that special protection should be given high-quality ground water and critical recharge areas. This represents a sober recognition of the nature of ground-water pollution. Polluted aquifers cannot be restored within the time frame of normal policy decisions. Conversely, the slow movement and limited mixing of contaminants underground allows the effective separation of contaminated and uncontaminated segments, which insures that a timely decision to protect existing high-quality ground water can be effectuated. This is not, however, to imply that unlimited pollution of other, lower-quality aquifers should be permitted. The protection strategy presented is prepared with this concept in mind and will not attempt to correct past mistakes except through the normal course of events (renewal of permits, upgrading of facilities, etc).

The recommended strategies will therefore be presented in two phases: the first dealing with immediately available options under existing authorities and programs with only slight modifications, the second dealing with longer-range, more controversial options.

A. Recommendations for Modification of Existing Programs

South Carolina appears to be in a relatively good position, to properly control ground-water contamination from most of the activities discussed in Section V. Unlike some states, major statutory authority to prevent pollution is centered in one agency (DHEC). This type of State organizational structure has been useful in facilitating State and

Federal coordination, and ground-water-quality management has been promoted and used within the diverse regulatory programs of DHEC.

The eighteen activities, cited in Section V as having the potential to contaminate ground water in South Carolina, will serve as the basis for recommending strategies. No changes in existing programs are recommended for:

- Disposal of wastes on the land
- Animal feedlots
- Stockpiles
- Infiltration of polluted surface water
- Surface impoundments
- Graveyards

The following activities suggest some study for possible positive changes in the way they are controlled. In most cases the necessary changes can be accomplished through minor modifications to existing regulations or by simple policy options within existing authorities.

1. Accidental spills - A formal policy is needed which clearly places more emphasis on the ground-water aspects of spills by establishing a goal of minimal ground-water impact. Such a policy could reduce the number of spills and minimize the damage done to the environment by placing liability for ground-water contamination on the responsible party. The standard emergency-response procedures briefly discussed in Section V should be modified regarding ground-water protection. Immediate

attention to ground-water-pollution abatement is called for. Ideally, technical appraisal should be made by a qualified geologist within two hours of the spill. The geologist could be an on-call employee of DHEC or a private consulting firm under contract. Certain industries should (be required to) maintain a spill contingency program that addresses ground-water protection in the event of a spill. Training programs for persons involved in the transportation and handling of hazardous materials and petroleum products should be strengthened to include ground-water-protection methods.

2. Fertilizers and pesticides - There is a need to strengthen Clemson University's regulation of pesticide and fertilizer application so that the prevention of ground-water contamination is an integral part of the decision-making process. A formal coordination mechanism is needed between Clemson University and DHEC to prevent situations such as the recent DBCP controversy regarding ground water. A joint ground-water investigation by DHEC and Clemson into the full extent of the existing contamination caused by fertilizers and pesticides is strongly recommended. The establishment of an adequate network of permanent monitoring wells should be included in the investigation. Training programs and public information programs should be modified to include an explanation of the potential ground-water-pollution problems and how they can be avoided.

3. Landfills - The existing laws and DHEC regulations, especially regarding hazardous wastes, are adequate to properly regulate future landfills. However, a major obstacle in the area of non-hazardous wastes is the economic limitation of most county governments which feel that the normal operation of the existing landfills is unduly expensive, not to mention the cost of ground-water protection measures and ground-water monitoring. A major effort is needed to shift emphasis toward the ground-water implications of landfills. When the need for ground-water protection is made clear and measures are required, there will be a natural tendency toward conservation and resource recovery, which should be encouraged as a method to reduce the burial of wastes in landfills.
4. Septic tanks - The present DHEC regulations controlling septic tanks have no provisions to take into consideration their collective impact unless an approval is sought for a sub-division. If the sub-division is not approved for septic tanks, the same situation can, and frequently does, develop with the same number of septic tanks on individual lots. Innovative on-site waste-disposal methods should be encouraged where ground-water quality is threatened and where a public sewage system is not available, either by strict interpretation of existing regulations or by technical assistance.
5. Leakage from underground tanks and pipelines (or underground storage tanks and transmission facilities) -

Presently there are no regulations dealing with leakage from underground tanks and pipelines in South Carolina. Unlawful discharges to ground water of this type account for the preponderance of ground-water-pollution cases investigated by DHEC. Because of the insidious nature of underground leaks, problems are usually hidden until property damage, aesthetic problems, and/or human-health effects occur. Today, DHEC approaches this problem on a case-by-case basis, however, seldom is there a simple or clear-cut solution.

The South Carolina Pollution Control Act provides DHEC with authority to control discharges of this type. In addition to DHEC, the South Carolina Department of Agriculture and the State Fire Marshall have concerns in petroleum storage and transport and should therefore be involved in development of regulations involving these practices.

Although the discussion presented herein deals primarily with leakage from petroleum storage and transmission facilities, equally important, and directly related, are chemical storage and transmission facilities. Oftentimes these industrial materials are more detrimental to human health and the environment than hydrocarbon fuels.

Even though underground storage and transmission facilities have been discussed, above-ground facilities cannot be absolutely segregated. The section on Acciden-

tal Spills discusses strategies to manage leaks (spills) from above-ground sources, however, the strategies listed below will be applicable, at least in part.

The following requirements, although general, should serve as a foundation for discussion and ultimately the formalization of the necessary regulations to protect human health and the environment from leakage from the large (greater than 1000 gallons) underground storage and transmission facilities:

- (a) Mandatory periodic testing for tightness of old storage tanks;
- (b) Mandatory testing for tightness of new storage tanks;
- (c) Registration of each storage tank, above a capacity of 1000 gallons;
- (d) Mandatory maintenance of accurate volumetric inventory records;
- (e) In the event of a leak or abnormal variation in inventory records, the Spill Control Program requirement to immediately contact DHEC, followed by implementation of the procedures outlined in the previous section on "accidental spills";
- (f) In any area where significant ground-water pollution is reasonably suspected due to poor operations, frequency of spills, or other cause, DHEC should require the operator of the storage or transmission facility to install monitoring wells to check

ground-water quality. If tests confirm that ground water is being unacceptably affected, the use of the facility should be discontinued until it is demonstrated that the source has been eliminated. Immediate steps should also be taken by the operator to restore the ground water to an acceptable quality within a reasonable amount of time. Procedures should be established to be used when the responsible individual can not be determined or when he is bankrupt.

6. Artificial recharge - The use of artificial recharge techniques are to be encouraged as long as they are accomplished in a sound technological manner, coupled with adequate water-management programs. The most important aspects of artificial recharge that need to be considered are the control and monitoring of the recharging water and of the resulting change in water level in the ground-water reservoir. Artificial recharge is not presently common but the demand on ground water will probably create the need for its use as a way to control water-level decline and possibly saltwater intrusion. Future artificial recharge facilities would best be managed by means of permits issued on the basis of hydro-geologic conditions and engineering design.

Some forms of artificial recharge such as heat-pump return flow wells, drainage wells, and salt-water barrier wells can best be controlled through the federally man-

dated Underground Injection Control Program implemented by DHEC. Others such as infiltration basins and spray irrigation should be managed as discharges to State waters under DHEC's State Contruction Permit Program.

7. Sumps and dry wells - Sumps and dry wells having the potential to contaminate ground water could be regulated through existing DHEC programs and the proposed regulations for the Underground Injection Control Program.
8. Injection Wells - The Pollution Control Act enables DHEC to control ground-water contamination resulting from injection practices and proposed regulations to accomplish this purpose (as required by the federal E.P.A. Underground Injection Control Program) have been submitted to the General Assembly for approval. These proposed regulations would ban existing and future injection of wastes except for oil and gas-related injection practices, solution mining, and certain other injection practices, all of which would require a permit. Heat-pump return flow wells returning essentially unaltered water to the aquifer would be authorized by rule, requiring only that notification be provided. These regulations have been through the public-hearing process, approved by the Board of Health and Environmental Control, and submitted to the General Assembly.

However, there is a conflict in that the Oil and Gas Act and pursuant regulations, authorized the Water Resources Commission to regulate injection practices

associated with oil and gas production. This has been characterized by industry as a duplication and a possible future source of controversy since Section 21 of the Oil and Gas Act prohibits the Water Resources Commission from usurping any " power, authority or responsibilities conferred upon the Department of Health and Environmental Control by Act 1157 of 1970" (the Pollution Control Act). In order to maintain consistency in the pollution control powers of the State, to enhance efficiency in permitting, compliance monitoring, and enforcement programs, and to streamline the shift of most environmental regulatory responsibilities (NPDES, Construction Grants, RCRA, UIC, SDWA, etc.) from the federal government back to the environmental protection department of state governments, it is recommended that the strategy include the approval of Underground Injection Control regulations proposed by DHEC.

9. Ground-water development (overpumping) - There is a close relationship between ground-water depletion and ground-water contamination. Overpumping almost always changes ground-water quality and, in coastal areas, saltwater intrusion becomes a major point of concern in the control of ground-water use. Sound management of the ground-water resource requires attention to the effects of contamination-control measures on depletion and depletion-control measures on contamination. However, in South Carolina the situation has evolved where separate

legislation has been developed to separately control pollution (Pollution Control Act) and ground-water depletion (Ground Water Use Act). The potential duplication underscores the need for a management approach. The essential elements of a management strategy to control or abate ground-water contamination from ground-water development should include:

- (a) Adequate technical data to provide an understanding of the occurrence, movement, and quality of ground water.
- (b) Adequate technical staff to analyze these data and sufficient funding to administer the management program.
- (c) Continual coordination among local, state, and federal officials to avoid unnecessary duplication of effort and provide for the maximum input by professionals involved in ground-water protection.

Specific recommendations for a management strategy to protect ground-water quality from salt-water intrusion include continuation of the Waccamaw and Low Country Capacity Use Programs. Emphasis should be shifted toward the critical areas, especially Hilton Head, to expedite the establishment of management goals. An acceptable amount of water-level decline has not been defined in either capacity use area and such a criterion is mandatory to equitably deny water-use permit applications and

to be the essential matter of contention in negotiations with other States, especially Georgia, regarding the effects of Savannah's pumping on South Carolina. Without a defensible criterion for acceptable and rightful water level, which is also applied to South Carolina ground-water users, it is doubtful that meaningful concessions would be made by the State of Georgia.

Second, the data-collection duplications between the ground-water programs in DHEC and WRC should be minimized. Both agencies (and USGS) currently collect and file basic ground-water data; DHEC in the Underground Injection Control Program, the Public Water Supply Program, the private well program, and the permitting and monitoring requirements of the regulatory programs (Solid and Hazardous Waste, Wastewater, Emergency Response); WRC in the capacity-use programs and for special ground-water reports. There is no need for the State to have duplicate files containing these data. Both filing systems use the same grid location system and little difficulty should be encountered in consolidating the files. The data should be computerized for ease of utilization and data interpretation. It is recommended that the existing computer capabilities of DHEC (as described by Shirley, 1982, in press), through EPA's STORET system, which is tied in with the USGS WATSTORE system, is the most economic and feasible method of initiating computer storage of basic ground-water and stratigraphic data.

10. Water supply wells - Proper well construction should have a dual purpose: to prevent contamination of the water pumped from the well, and at the same time to prevent contamination of the aquifer upon which the well depends. If a well is adequately constructed and maintained to accomplish the first purpose, which is the emphasis of most state water-supply and well drillers certification programs, the second will also be likely served. Regarding public water-supply wells, South Carolina is properly prepared to protect ground-water quality and no changes in authority are needed.

However, there are many water-supply wells drilled each year which are not public supplies, including domestic, irrigation, industrial, geothermal, and livestock watering wells. Recently passed legislation requiring certification of water well drillers and the establishment of minimum construction standards for all wells provides the basis for properly controlling well-construction and location. The well-construction standards to be developed by the legislatively mandated Advisory Committee to the Board of Health and Environmental Control should place emphasis on the protection of ground-water quality after the well is abandoned, as well as during its operating life, e.g., long gravel packs should be prohibited, grout collars between screens should be required, test holes and abandoned wells should be properly plugged, back-flow prevention should be required for irrigation wells, etc..

In the two areas declared capacity-use areas (Waccamaw and Low Country) there is duplication, including two separate permits, for public water-supply wells. An attempt should be made to consolidate the two permits into one, joining the depletion-control and contamination-control conditions. Since over 90 percent of the wells drilled in capacity-use areas (other than domestic) are public, it is recommended that the permit required by the State Safe Drinking Water Act, be used as the primary permit and the depletion-control conditions as recommended by WRC be attached thereto.

For non-public wells the well-construction and abandonment standards to be developed in 1983 by the advisory committee to the Board of Health and Environmental Control should be the mechanism used to prevent ground-water contamination in those instances.

11. Underground storage - The only deep natural gas storage operation in the State has been cooperative with DHEC in submitting plans and specifications, in monitoring of ground-water quality and levels, and in reporting apparent problems. However, the operators of future storage facilities may not be as cooperative and it is felt that regulations are necessary to clearly require ground-water-quality protection. The State of Georgia recently enacted an ordinance addressing the control of the one natural gas storage cavern in Georgia, which could serve as a model for a similar regulation in South Carolina.

B. Recommendations for Major Modifications to Ground-Water-Protection Policies

In a broader perspective, there are several overriding strategic elements, crossing the lines between the previously discussed activities, which are considered essential for the proper protection of the ground-water resource. The Senate Resolution has fulfilled the first need by recognizing the unique economic value of ground water and the benefits of exercising a high level of protection. The absence of a state-supported program and a well-defined goal, which clearly have as their purposes the protection of ground-water quality, is a major obstacle, rooted in the hodgepodge of federal laws dealing with ground water. The proposed Environmental Protection Agency Ground Water Strategy appears to be an initial step toward setting a ground-water protection goal at the federal level. However, it comes at a time when the responsibility for many programs, including the implementation of ground-water protection programs, are being shifted from the federal government back to the states. This provides an excellent opportunity for South Carolina to establish its own goals and carry out a comprehensive ground-water-protection program suited to the needs of South Carolina without reliance on federal requirements.

The recommended management strategy should be built around three basic points. First, the highest priority should be assigned to the preservation of high-quality aquifers. Second, the water-quality objective for such aquifers should

be non-degradation. Finally, the major mechanism for achieving the non-degradation of high-quality aquifers should be the regulation of land use to prohibit polluting activities within critical recharge zones.

It is to South Carolina's advantage that a large portion of suspected recharge areas within the state are undeveloped. This provides a unique opportunity for the State to avoid many of the problems of contaminated ground water as found in other states, as well as allowing the use of innovative techniques of aquifer protection.

An extensive mandate exists for the protection of ground water. The mandate is for prevention of contamination rather than increased treatment at the point of withdrawal. Inherent in the interpretation of the mandate is the need to balance the economic considerations of benefits to the environment against regulatory costs.

The only federal provision that uses recharge zone protection as an approach to ground-water management is the Gonzales Amendment of the 1974 Safe Drinking Water Act. The amendment provides local, regional, or state agencies a legal mechanism to protect the recharge zones of special aquifers. If an area can be shown to have an aquifer which is the sole or principal drinking-water source which, if contaminated, would create a significant hazard to public health, then the EPA Administrator upon his own initiative, or by petition, may designate the aquifer as "sole source". After designation no federal financial assistance may be given for any project

which the Administrator determines may contaminate the aquifer through a recharge zone so as to create a significant hazard to public health.

Only four or five aquifers in the United States have been declared sole source under this provision. It remains however a very powerful tool. Since projects such as highways, housing, and waste-treatment facilities are partially funded with federal monies, the ability to control those funds may be a significant determinant of, and prerequisite for, development in an area. It is proposed that, at the completion of the South Carolina 208 Recharge Area Assessment, an application be made to the EPA Administrator to declare the Tertiary Limestone Aquifer in South Carolina a sole source aquifer.

Other less specific federal mandates for ground-water protection which could be used toward critical recharge area management include the Clean Water Act (CWA) and the Resource Conservation and Recovery Act (RCRA).

Several sections of the CWA call for ground-water protection measures which could be implemented by mapping, and protecting critical recharge areas. Section 102 requires a comprehensive program for the prevention, reduction, or elimination of pollution to ground water, as well as an improvement of the sanitary condition of underground waters.

Section 106(e)(1) of the Act authorizes Federal grants to states for the administration of pollution control programs. A state is required to carry out a ground-water quality monitoring and evaluation program to be eligible for such grants.

As the Ground-Water Protection Division currently maintains such a ground-water quality monitoring and evaluation program, a possible source of funds for a critical recharge area protection program is Section 106 of the CWA.

Section 208 of the CWA requires the development of Water Quality Management Plans to meet the goal of restoring and maintaining the chemical, physical, and biological integrity of the Nation's waters, including ground water. The Ground-Water Protection Division is currently utilizing Section 208 for preliminary investigations of likely critical recharge areas. There are benefits of using the 208 planning process for aquifer protection zone planning in that there is a built-in public participation program. This provides a forum for public education on the problems of ground-water contamination, as well as a means to receive input from the general public.

A final federal mandate for the protection of critical recharge zones is found in Sections 4002 and 4003 of RCRA. These sections call for a state solid waste management plan which provides for solid waste management in an environmentally sound manner.

On the state level there is also a clear mandate for the protection of ground-water resources. The South Carolina Pollution Control Act (PCA) gives DHEC the power to conduct studies, investigations, and research in order to prepare a general comprehensive program for abatement, control and prevention of air and water pollution.

It has been demonstrated that the mandate and need to provide for ground-water protection and management exists. The main element of such a program has to be a definition of the extent and physical characteristics of the aquifers involved. Important to the description of the aquifer systems is the delineation of the critical recharge zones for these aquifers.

The critical recharge zone maps by necessity would be general at the beginning of the program. The maps would be general outlines of the subcrop areas of the major aquifer systems. Then within each general area, site specific information provided by facilities applying for a permit for a land disposal operation would be used to define critical areas in more detail. These maps would require constant refinement as new information about an area is generated. New information, such as hydraulic-head relationships, ground-water ages, potentiometric head responses to pumping and rainfall events, and stratigraphic information such as geologic/geophysical logs, would be gathered as part of a continuing program to review and refine recharge-area boundaries.

The standards for recharge-zone protection would be based on an aquifer-classification scheme. This would allow different levels of protection to be afforded aquifers of various quality.

The highest category would contain "Priority" aquifers. This would include aquifers which have been determined to be sole source, or of exceptional ecological importance. A

nondegradation standard would be applied in the recharge zone of priority aquifers. Solid and hazardous waste disposal facilities would be excluded. Only the highest quality wastewater, clearly capable of being renovated by soil and vegetation, could be discharged to the land. New development would be discouraged in the area.

Aquifers classified in the "Intermediate" category would include all actual or potential drinking-water sources and aquifers whose contamination would affect surface water. Waste-disposal facilities within the recharge zones of these aquifers would be required to meet strict performance standards to prevent violations of drinking water or other established standards.

The third category would be "Secondary", which would include all aquifers not falling into "Priority" or "Intermediate" classifications. Facilities within the recharge zone of these aquifers must meet only basic performance standards.

Protection of critical recharge zones may be accomplished many ways. As already discussed, existing federal and state laws and programs could be used to establish regulations and guidelines for aquifer protection. These could range from sole source aquifer designations to ground-water quality standards, and state discharge-to-ground-water permits similar to the NPDES program for surface-water discharges.

The major thrust of any aquifer-protection program should include an educational element to heighten public awareness of the problem with ground-water contamination. Coupled with

this education effort should be a program informing local and regional governing bodies of the means they have for producing effective ground-water protection efforts.

Some of the local options for ground-water protection through management of recharge zones include:

1. Land use zoning restrictions.
2. Development density zoning restrictions.
3. Surcharges by water utilities on water consumption to provide monies to purchase recharge areas. As an alternative if the local governing body decides against recharge zone management the monies could be used to provide treatment when the water supply wells become contaminated.
4. Financial incentives offered to move development out of recharge areas into non-recharge areas.
5. Area-wide sewerage with strict construction standards to prevent leakage from sewers.
6. Restricting the use of certain products within recharge areas (liquid fertilizers/pesticides-herbicides, degreasers, etc).
7. Examine properties with tax liens to determine if local government should retain the properties to control development.
8. Maintain areas in natural state by restricting road construction.

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Table 1. Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Savannah River Plant	Aiken/Barnwell	Large areas of contamination. Multiple plumes. Fate - nearby surface water (streams).	Radionuclides, metals, organics	Infiltration basins and others	None	Ground water has been studied in great detail with further study planned. The State has only recently been authorized to regulate. A complete ground-water monitoring report is forthcoming.
Samples private well	Aiken	Localized near well.	Oil	Submersible pump	1 private well	Private well analysis detected 0.61 mg/l pump oil. Clean-up recommendations offered well owner.
Valchem Corporation	Aiken	Lateral extent - localized in spill area (~ 1 acre). Vertical extent at least 20 feet. Fate - Horse Creek.	Organics, primarily ethyl acrylate	Improper well construction, spills	1 production well	Problem discovered due to taste and odor problem in Langley Water District. Contaminated production well cross-connected onto Langley system. Ground-water contamination investigation by SCDHEC (1975) indicated source and extent of contamination. Spill prevention measures now employed. No cleanup.
J. P. Stevens	Allendale	100'/1500'>35' Fate - Miller Creek and deeper aquifer.	Nitrate	Sludge injection	None	Contaminated ground water is impacting creek (9.8 mg/l nitrate). Continued monitoring in progress.
Sandoz Colors and Chemicals	Allendale	Lateral extent - estimated to cover 132 acres. Vertical extent - at least 45 feet.	Sulfate, nitrate	Spray irrigation	None	Shallow aquifer contamination discharging to Savannah River was the concept of the original permit. Apparent contamination of deeper aquifer is under investigation by the company.
Puretown Restaurant and Truck Stop	Anderson	Lateral extent - unknown Vertical extent - ~ 200' Fate - unknown	Nitrate	Septic tank	1 public well (non-community)	Well has been abandoned and replaced with city water.
Tribble private well	Anderson	Localized near well.	Gasoline	Under-ground storage tanks	1 private well	Well is bored (~ 42 feet deep) and located at service station. No paved driveway to prevent spill infiltration. City water not available.
True Temper Corporation	Anderson	Localized near lagoons. Fate - Beaver Creek.	Metals	Lagoons	None	All industrial waste effluent tied into sanitary treatment system. Monitoring ceased in 1976.
Starr Landfill Permit No. DWP-033	Anderson	Extent - perimeter of landfill. Vertical extent - ~ 40' Fate - nearby surface waters.	Metals, organics	Landfill	None	Continued monitoring required.
Beaufort County Landfill DWP-063	Beaufort	Lateral extent - localized on landfill property in surficial aquifer. Vertical extent - at least 33'. Fate - to lower parts of surficial aquifer. Potential to recharge Tertiary Limestone Aquifer.	Nutrients, organics	Landfill	None	SCDHEC study presently being conducted. Landfill recently closed out (operated for 12 years) through May 1982. Numerous limestone water-supply wells nearby. Near center of Burton recharge area.

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Independent Nail (formerly Blake and Johnson)	Beaufort	At least 50'/?/at least 55' Fate - lower parts of surficial aquifer. Potential to recharge Tertiary Limestone Aquifer.	Nitrate, metals	Lagoon	None	In 1980, high concentrations of metals and nitrates detected. Lagoon improperly abandoned. Recent analyses indicate decreasing trends in concentration. In Burton recharge area.
Holder private well	Beaufort	Extent - unknown. Depth - >50'. Fate - unknown.	Fuel oil	Abandoned well	1 private well	Well mistaken for fuel oil tank intake in 1975. Large amount of fuel oil pumped into well tapping the Tertiary Limestone Aquifer. About 500 gallons pumped out.
Kalama Specialty Chemicals (formerly Vega Chemicals)	Beaufort	Lateral extent - ~ 1 acre. Vertical extent - at least 55'. Fate - recharge potential for Tertiary Limestone Aquifer is high.	MBAS, metals, organics	Tile field, lagoon, drum storage surface, run-off, spills	None	SCDHEC and the company have investigated contamination. Tile field and lagoon have been closed out. Spill prevention measures required at drum storage and production areas. Company tentatively plans to shut down in 1983. Near center of Burton recharge area.
Royal Pines Subdivision	Beaufort	Extent - localized near spill area. Fate - nearby surface waters.	Nutrients	Fertilizer spill(s)	None	Spills near golf-course maintenance sheds. Ammonia (71 mg/l), phosphorus (16 mg/l). Wells installed by SCDHEC.
Sea Pines Plantation water-table aquifer	Beaufort	Numerous plumes. Fate - surface waters. Some potential for recharge to Tertiary Limestone Aquifer.	Nutrients	Septic tanks, spray irrigation, lagoons	None	SCDHEC study (1981) found ammonia, detergents, and bacteria in ground water in several areas.
Wamchem (Beaufort) Chemical Company	Beaufort	Multiple plumes. Lateral extent - ~ 3 acres. Vertical extent - at least 30'. Fate - McCalley's Creek, recharge potential unknown.	Nutrients, metals	Spray field, unlined lagoons, pits, spills	1 public well (non-community)	Facility is now closed. Investigation required by SCDHEC prior to closeout.
Hanahan Defense Fuel Depot	Berkeley	~500'/~500'/~35' Fate - nearby surface water.	Jet fuel (JP-4)	Spills	None	Primarily nuisance problem. During wet weather, water table (and fuel) surfaces in residential area, causing odor problem. Studied by SCDHEC and Defense Department.
Santee River Wool Combing Company	Berkeley	Shallow aquifer underlying ~ 10.9 acres is contaminated to a depth of at least 30'. Fate - Santee River.	Nutrients, metals, phenols	Sludge landfill	None	Sludge from anaerobic lagoon pumped into landfill for disposal. Continued study in progress.
Brown private well	Calhoun	Localized near well.	Gasoline	Unknown	1 private well	
Carolina Eastman	Calhoun	~1000'/~600'/at least 37' Fate - Congaree River.	Metals, nitrate	Spray irrigation	None	Spray irrigation area has been enlarged to reduce application rate and induce plant uptake of nitrate. Continued monitoring.

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Culclasure private well	Calhoun	Localized near well.	Oil	Damaged submersible pump	1 private well	Private well analysis detected 1.88 mg/l submersible pump oil. Clean-up recommendations offered.
Wiles private well	Calhoun	Localized near well.	PCB's	Submersible pump	1 private well	1.01 ug/l PCB's. Suspected source is pump damage.
Charleston Shredder	Charleston	Lateral extent - localized in shredder area. Vertical extent - restricted to shallow aquifer. Fate - Charleston Harbor.	Metals, nutrients	Landfill	None	Three SCDHEC monitoring wells determined leachate not moving downward. Situated on dredge material near Cooper River and underlain by the highly impermeable Cooper Marl.
Culligan Water Treatment Company	Charleston	Lateral extent - localized. Vertical extent - restricted to shallow aquifer (~ 30'). Fate - Shem Creek.	Organics	Septic tanks, accidental spills	1 public well	Trace concentrations of tetrachloroethylene and trichloroethylene detected in laboratory-process water in 1977. Culligan building previously a dry-cleaning establishment. Underlain by the Cooper Marl.
Cummins Engine Company	Charleston	Extent - at least 4 acres of shallow aquifer contaminated to depth of ~ 10'. Fate - Ashley River	Metals, sulfate	Lagoons	None	Monitoring wells installed as requirement of State Hazardous Waste Permit. A geohydrologic report has been submitted. Continued monitoring in progress. Underlain by Cooper Marl.
Edistonian Laundromat	Charleston	Small contaminated area. (~50'/~100'/at least 18') Fate - nearby surface water.	MBAS, sulfate	Septic tank	None	SCDHEC study (1980) found failure of system (ponding) due to overload-ing. Underlain by Cooper Marl.
Folly Island	Charleston	Extent - unknown. Probable fate - nearby surface waters.	Bacteria, nutrients	Surface-water infiltration, septic tanks.	None	May have necessitated water line in 1950's. Underlain by Cooper Marl. SCDHEC study (1980) determined shallow aquifer degraded by nutrients from tile-field effluent.
Mobil Chemical Company	Charleston	~200'/?/<35' Fate - Ashley River.	Ammonia, dichlofenthion (DCFT)	Abandoned transmission lines	None	Discovered by discharge into river. Upgrading of facility in progress to prevent future leaks. Soil is being tested for DCFT content. Further study in progress. Underlain by Cooper Marl.
Trident Landfill DWP-005	Charleston	Lateral extent - landfill perimeter. Vertical extent - at least 20'. Fate - nearby surface waters	TOC, heptachlor	Landfill	None	Monitoring wells installed by SCDHEC. Site underlain by Cooper Marl.
Broad River Brick	Cherokee	~200'/?/>20' Fate - unnamed tributary of Broad River.	Fuel oil	Spill in fuel storage area	None	Discovered as discharge into tributary of Broad River.
Carolawn Industry	Chester	Lateral extent - unknown. Vertical extent - greater than 40'. Fate - deeper parts of bedrock aquifer and nearby creek.	Organics	Hazardous waste storage	1 private well	Discovery through routine monitoring of surrounding domestic wells.

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Industrial Chemical Company Landfill IWP-105	Chester	~350'/~200'/at least 15' Fate - Wildcat Creek.	Metals, organics	Landfill	None	Two monitoring wells installed by SCDHEC indicate landfilling activities are impacting ground water. Proposal to install an upgradient and additional downgradient wells to meet Hazardous Waste Management Regulations has been submitted.
Windsor Park Subdivision	Chesterfield	~300'/~1200'/~25' Fate - small unnamed creek.	Bacteria	Sewage infiltration	12 private wells	Subdivision with individual shallow bored wells. Area is sewered but man-holes were not properly constructed. City water is now used.
Federal Mogul	Clarendon	Exact extent unknown. Lateral extent - ~75' Fate - nearby surface water	Metals	Transmission lines	None	Underground broken sewer line process water to enter ground water. Discovered as seepage into ditch. Further study needed.
Nelson private well	Clarendon	Localized near well.	Gasoline	Under-ground storage tank	1 private well	Gasoline (2.0 mg/l).
Paxville private wells	Clarendon	Multiple plumes. Lateral extent - unknown Vertical extent - at least 20'.	Gasoline	Under-ground storage tanks	At least 2 private wells	Private wells located near three service stations.
Astin-Hill Manufacturing	Colleton	Extent - undetermined. Fate - nearby surface water.	Phenols	Lagoons	None	SCDHEC monitoring well contained 100 ug/l phenols and specific conductivity 750 umhos/cm in 1979. Lagoons are being phased out.
Balchem Corporation	Colleton	~200'/~100'/at least 10' Fate - Ashepoo River.	Organics	Unlined lagoon	None	Ground-water monitoring continuing. Lagoons are scheduled to be lined.
Carraway private well	Darlington	Localized near well.	Gasoline	Under-ground storage tank	1 private well	Discussions with owner indicates abandoned storage tank (500 gallons) used as farm supply may be cause of problem.
Darlington County Landfill DWP 060	Darlington	Lateral extent - landfill perimeter. Vertical extent - ~ 15'. Fate - Bellyache Creek.	Metals	Landfill	None	Maintenance problems, such as non-installation of daily cover contributes to ground-water problem.
Johnson private well	Darlington	Localized near well.	Gasoline	Under-ground storage tank	1 private well	Two samples showed 1.1 and 1.6 mg/l gasoline. County water available.

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Sonoco	Darlington	Large area of shallow contamination (~2400'/~10,400'/~50') Fate - Black Creek.	BOD, TDS, TOC	Landfills, lagoons, spray irrigation	None	Complete ground-water investigation near completion. Alternative waste-disposal methods to be considered. Restricted to shallow aquifer.
Johnson Bronze	Dorchester	Slight contamination limited to shallow aquifer (~30'). Probable fate - Rumphs Hill Creek.	Metals	Improper disposal of metal wastes	None	SCDHEC and company monitoring wells indicate ground water contaminated with metals, lead (0.07 mg/l) and chromium (0.15 mg/l). Site underlain by Cooper Marl.
Pantry Shelf Convenience Store	Dorchester	Extent - localized in spill area. Probable fate - Chandler Creek.	Gasoline	Transmission lines	None	Leak reported by facility. Leak located between underground gasoline storage tank and distribution pump.
Rosa Small private well	Dorchester	Localized near well.	Gasoline	Suspected underground storage tank	1 private well	SCDHEC study (1976) determined nearby service station as source. Contamination restricted to shallow aquifer by underlying Cooper Marl.
Morrison private well	Edgefield	Extent - unknown. Fate - unknown.	DBCP	Peach orchard application, abandoned wells, spills	3 private wells	Low level (1 to 5 ppb) of the nematocide have been confirmed in several private and SCDHEC wells. Application ban issued by EPA. Exemption (1982) for use of DBCP by South Carolina peach growers withdrawn.
Williams private well						
Yonce private well						
Edgefield County Landfill DWP-040						
Scurry private well	Edgefield	Localized near well.	Gasoline or fuel oil	Spill/leak	1 private well	Private well located near truck stop.
Sweetwater Community	Edgefield	Large area of shallow contamination (1200'/600'/~40') Fate - nearby surface water.	Petroleum	Spill/leak, lines/tank	1 private well 1 spring	Studied by SCDHEC in 1979. Contamination is low-level. Discovered in a private well located near petroleum storage area.
Covington private well	Edgefield	Localized near well.	Gasoline, chloroform	Unknown	1 private well	Service station located nearby. No septic tank located on property.
Dupont Sludge Disposal Site	Florence	Large area (~10 acres) of shallow contamination (at least 25' in depth) Fate - tributaries to Great Pee Dee River.	Nitrate	Spray irrigation	None	Monitoring wells indicate NO ₃ as high as 32 mg/l after 4-5 years in operation. Alternative waste-disposal methods to be implemented in Spring, 1983.

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Eaddy's Phillip's 66 Station	Florence	~ 100'/~200'/>10' Probable fate - storm drains, nearby surface water.	Gasoline, fuel oil	Leaks, underground pipe and storage tank	None	Contamination investigated only after storm drain in Lake City caught fire. Appear to be several sources of gasoline and fuel oil. Indications of numerous previous spills. Recovery action to collect gasoline proved semi-effective.
Hutchinson Trailer Park	Florence	Localized near well.	Nitrate	Septic tank	1 public well	Nitrate (11.4 mg/l) in public water supply. City water now used.
Kopper's Company Incorporated	Florence	Large area contaminated by plume (2500'/500'/>50') Fate - unknown.	Creosote	Lagoon/landfarming	2 private wells	Studied in 1981 by SCDHEC. Further study by the company in progress to determine plume dimensions and fate. Sources removed.
Georgetown Steel and Ferreduction	Georgetown	Extent - ~ 11.0 acres contaminated to depth of ~ 30'. Fate - nearby surface water, possible contamination of underlying limestone aquifer.	Metals, nutrients	Landfill/abandoned dump	1 private well	SCDHEC study (1980) detected elevated levels of metals and nutrients. Further studies by company. Worst source has been capped with clay. Underlain by old county dump.
Pawley's Island Laundromat	Georgetown	Lateral extent - perimeter of spray field. Vertical extent - ~ 20' Fate - nearby surface water.	MBAS	Spray irrigation	None	Four monitoring wells sampled 3 times in 1 year at this spray irrigation facility. MBAS detected in each, as high as 38 mg/l (SCDHEC study, 1980). Site conditions include very permeable surficial sands, and shallow water table.
Strickland private well	Georgetown	Approximately 5 acres, contaminated to a depth of 30 to 35 feet. Fate - Murrell's Inlet.	Saltwater	Dredge spoil	1 private well	Salty dredge spoil placed in abandoned coquina mine. SCDHEC wells indicating high conductivity were used to determine extent of plume.
American Hoechst	Greenville	~170'/?/~18' Probable Fate - White Plains Branch. Small area of contamination	Metals, organics	Lagoon	None	Lagoon close-out is completed.
Carolina Plating	Greenville	(~50'/~200'/16') Fate - Reedy River, possible contamination of bedrock aquifer.	Metals	Lagoon	None	Lagoon close-out is planned.
Colonial Pipeline Company Spill Site 1	Greenville	Large area of contamination (~200'/400'/~25') Fate - Little Durbin Creek.	Fuel oil, TOC	Transmission line rupture	None	Spill 1 occurred on May 13, 1979 when 394,128 gallons of home heating fuel escaped from a ruptured pipeline. 129,528 gallons were not recovered. On June 16, 1979, at spill 2, 394,800 gallons of home heating fuel oil escaped from a 7-foot long rupture in a pipeline. Of this amount a reported 32,130 gallons were not recovered. The facility installed monitoring wells at both sites which indicate increasing concentrations in TOC.
Colonial Pipeline Spill Site 2	Greenville	~700'/~1000'/at least 40' Probable Fate - Durbin Creek.	TOC, fuel oil	Transmission line rupture	None	

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Crown Metro	Greenville	Area of contamination small localized in lagoon area. Organics found at depth of ~ 5'. Fate - Huff Creek, bedrock aquifer.	Organics	Lagoons	None	Further study is planned.
General Battery	Greenville	1200'/400'/25'-30' Fate - White Plains Branch, potential vertical migration to bedrock aquifer.	Metals, acid	Abandoned lagoon, chemical handling/storage areas	None	SCDHEC investigation (February 1979) found shallow aquifer contaminated. Further study to determine dimensions of plume and methods for ground-water recovery in progress by company.
Greenville County Service Center	Greenville	Long, narrow plume (~90'/~30'/~5' thick - 9'-14') Fate - nearby surface water,	Gasoline	Unknown	None	Contamination detected when gasoline seeped into excavation. Suspected source(s) are as stated.
Para-Chem Southern	Greenville	Lateral extent - known to be at least 6' from lagoons. Vertical extent - 30', Probable fate - Durbin Creek, bedrock aquifer.	Phenolics, lead	Lagoon	None	Further study is planned.
Union Bleachery	Greenville	Area of contamination localized in bank of Langston Creek, the area below facility's dam and pumping station. Probable fate - Langston Creek bedrock aquifer.	Chromium	Unknown	None	High chromium concentrations found in Langston Creek (bordering facility) initiated ground-water investigation. Ground water found to contain as high as 2740 mg/l. Ground-water recovery program initiated. Bedrock aquifer also contains elevated chromium concentrations.
Western Carolina Public Sewer Authority IWP-052	Greenville	Lateral extent - Unknown. Vertical extent - at least 15'. Probable fate - unnamed stream, bedrock aquifer.	Phenols, metals, TOC	Landfill	None	More extensive ground-water monitoring well network planned.
Westinghouse Electrical Company	Hampton	~500'/~250'/~50' Probable fate - Sanders Branch.	Phenols	Lagoons, tank farm/pump house area, spills	None	SCDHEC report (April 1980) found concentrations up to 234,000 ug/l. Recovery program soon to be in operation.
AVX Corporation	Horry	~240'/7'/~15' Fate - nearby ditch, surface water, possible vertical migration.	Chromium, TOC	Sludge disposal	None	Previous facility owner, American Gear and Pinion, disposed metal-bearing sludge into ditch and then covered. Present owner investigating possibility of vertical migration of contaminants.

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Garden City Shopping Center	Horry	Lateral extent - at least 132' from lagoon. Vertical extent - at least 26'. Probable fate - nearby surface waters, vertical migration to deeper aquifer.	TDS, MBAS	Lagoon	None	Nine SCDHEC monitoring wells around this unlined, aerated, oxidation lagoon for domestic wastewater. Besides contaminants listed, elevated concentrations of nutrients were detected 40 meters from lagoon. Site conditions include very permeable surficial sands and high water table.
Grove Manufacturing Company	Horry	~50'/670'/~10' Fate - nearby surface water.	Metals	Disposal area	None	Improper disposal of listed hazardous waste led to ground-water contamination by mercury and barium. Further study in progress by company.
Myrtle Beach Air Force Base	Horry	Shallow ground water contaminated within approximately 1/2 acre area. Probable fate - nearby ditch.	Jet fuel (JP-4)	Spill	None	120,000 gallons spilled. French-drain recovery system installed immediately after spill in January, 1980. 75-100 gallons/day recovered. Further recovery planned.
Pine Valley Estates	Horry	Small area of contamination (at least 20'/70'/12') confined to shallow aquifer. Probable fate - Schoolhouse Branch.	Ammonia	Holding ponds	None	Elevated ammonia concentrations (over background) indicate contamination of confined shallow aquifer.
Scotchman Convenience Store	Horry	~400'/~100'/water-table surface. Fate - nearby surface water.	Gasoline	Underground storage tanks	None	Gasoline found in manhole in October, 1981. SCDHEC investigated, installed monitoring wells and advised appropriate personnel regarding safety hazards due to presence of explosive levels of gasoline vapors in manhole, and in recovery trench. Clean-up actions are not presently required. Flash fire occurred recently (November, 1982) due to explosive gasoline vapors.
Seabreeze Trailer Park	Horry	Lateral extent - known to occur at tile field perimeter. Vertical extent - ~ 15'. Fate - nearby surface water.	Nitrate	Septic tanks	None	Two wells in area of small, concentrated tile fields. Three to four trailers share a single septic tank/tile field, which receives poor effluent re-novation from permeable sediments and high water table. Concentrations as high as 26 mg/l detected in 1980.
Strickland private well	Horry	Localized near well.	Organics	Improper storage of chemicals near well, poor well construction	1 private well	Lasso (1.73 mg/l), Carbofuran (4.0 ug/l), Carbaryl (0.36 ug/l).

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
E.I. DuPont May Plant	Kershaw	Lateral extent - lagoons perimeters. Vertical extent - at least 10'. Fate - Wateree River, migration to deeper aquifer.	Metals	Lagoons	None	Monitoring wells adjacent to lagoons detect chromium and mercury concentrations above standards.
Lugoff-Elgin Landfill . DWP-008 & 8A	Kershaw	Lateral extent - localized at landfill perimeter. Vertical extent - ~ 15'. Probable fate - Flat Branch.	Metals	Landfill	None	Monitoring wells installed by SCDHEC in fulfillment of Open Dump Inventory Agreement. Elevated metals concentration constitute classification as open dump.
Wade Small Residence	Kershaw	Localized near seep area.	Pesticide	Burial of pesticide containers	None	Basement water seep contained pesticides.
Lancaster City Landfill DWP-025	Lancaster	Lateral extent - limited to landfill perimeter. Vertical extent - at least 15'. Fate - Camp Creek, bedrock aquifer.	Metals, organics	Landfill	None	Monitoring wells installed by SCDHEC as part of Open Dump Inventory detect elevated levels of metals and organics. Constitutes classification as open dump.
Lehigh-Lancaster	Lancaster	~300'/~300'/~20' Fate - Turkey Quarter Creek.	Metals, acid	Lagoons	None	Waste sulfuric acid lagoons have been close out and replaced with treatment system and regional sewer discharge.
Moses private well	Lancaster	Localized near well.	Gasoline	Unknown	1 private well	Private well analysis indicated gasoline (8.9 mg/l) present in well water.
Simpson private well	Laurens	Localized near well.	Fuel oil	Above ground storage tank	1 private well	Fuel oil contamination in a private well thought to be result of leaky above ground home fuel tank. Public water not available.
Torrington Company	Laurens	Small plume of contamination. (100'/?/at least 15') Fate - unnamed tributary of North Creek.	Mercury, flouride	Hazardous waste storage impoundments	None	Monitoring continuing.
Lee County Landfill DWP-038	Lee	Lateral extent - perimeter of landfill. Vertical extent - at least 25'. Probable fate - Lynches River.	Metals	Landfill	None	Landfill monitored (SCDHEC monitoring wells) as part of Open Dump Inventory. Elevated metals concentrations constitute classification as open dump.
Allied Fibers and Plastics Corporation	Lexington	~1000'/~500'/at least 20' Fate - Saluda River	Metals, nutrients, TDS, phenols	Unlined lagoons	None	Ground-water investigation conducted as part of facility's overall environmental assessment. Elevated concentrations of metals localized near lagoons. Impact is apparently limited to on-site shallow-water-table aquifer. Monitoring continuing.

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Carolina Chemical Company/ Columbia Metropolitan Airport	Lexington	Large area of contamination. (At least 600'/?/200'/?/40') Probable fate - vertical migration to deeper aquifers, Six Mile Creek.	Pesticide	Landfill	None	Unpermitted burial of empty pesticide bags resulted in contamination of shallow aquifer by Lindane (43 ug/l) and Toxaphene (570 mg/l). Further study in progress.
Carolina Gravure	Lexington	Extent - contamination presently found in perched water-table aquifer (~50'/?/50'/?/20') Probable fate - migration to deeper water-table aquifer and Middendorf Aquifer.	Metals	Lagoon, spray irrigation	None	Ink wastes disposed of via pits in sand with some spray irrigation. Lead as high as 5.6 mg/l, chromium 0.62 mg/l, cadmium 0.781 mg/l. At present, facility cooperating with SCDHEC in study of possible recharge areas.
Columbia Metropolitan Airport	Lexington	Large area contaminated. ~300' to north, ~155' to south of spill area. Fuel trace found 48' below ground surface. Fate - unknown.	Aviation fuel (JP-4)	Spills	None	Fuel storage area spill discovered in surface waters which have now been cleaned up. Five monitoring wells installed by SCDHEC. Indications of prior spills. Appears several spills have occurred in area.
Dutchman Shores Subdivision	Lexington	Lateral extent - unknown. Vertical extent - at least 35' Fate - Lake Murray.	Bacteria	Septic tanks, surface runoff	1 public well	SCDHEC report (February 1981) concluded the widespread occurrence of bacteria in shallow aquifer result of high density of septic tanks in area and surface runoff.
Frink Street and U.S. 321 gasoline seep	Lexington	Extent - unknown Fate - nearby surface water	Gasoline	Suspected underground gasoline storage tanks	None	Gasoline contaminated ground water seeped into excavation. Excavation constructed to repair water lines (possibly affected by gasoline). Suspected source: nearby abandoned underground gasoline storage tanks.
Leesville	Lexington	Localized near well.	Petroleum	Unknown	1 public well	New city well could not be used.
Leesville	Lexington	Lateral extent - unknown. Vertical extent - at least 100' Fate - dilution in aquifer.	Organics	Unknown	2 public wells	Eight organics found in 2 public drinking water supply wells. Suspect organics are from degraded petroleum products. Possibly related to previous entry.
Padgett Poultry Farm	Lexington	150'/?/30' Fate - nearby surface water.	Nitrates	Surface infiltration	1 private well	Abandoned well. Presently using another water-supply source.
Parkwood Subdivision water-table aquifer	Lexington	Two plumes from same source caused by two flow regimes. a) 200'/?/at least 50' b) 100'/?/at least 50' Fate - nearby stream/deeper aquifer (?).	Gasoline	Suspected underground gasoline storage tank(s)	3 private wells	SCDHEC investigations have not been able to determine source(s).

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Power Oil Company	Lexington	Small area of contamination. Fate - storm drains, nearby surface water.	Gasoline	Under-ground transmission line	None	Facility reported loss of 200,000 gallons (suspected) regular grade gasoline leaked from underground transmission lines connecting tank and distribution pumps. Remedial or recovery actions not economically feasible.
South Carolina Recycling and Disposal (Dixiana site)	Lexington	~130'/~140'/30-70' Fate - undetermined.	Metals, organics	Surface infiltration, stockpiles	2 private wells	SCDHEC (1981) conducted ground-water contamination investigation. The site has been scheduled for clean-up action funded by EPA Superfund.
Springdale private well	Lexington	600'/150'>20' Fate - deeper aquifer recharge.	Gasoline	Spills	1 private well	SCDHEC study (August 1980) concluded source to be gasoline station leaking gasoline from aboveground storage tanks. City water now used.
Inland Container Company	Lexington	Intermittant contamination evidenced in wells adjacent to lagoon (~ depth 5'). Fate - unnamed tributary of Twelve Mile Creek	Metals	Septic tank/tile field	None	Chromium (0.82 mg/l) and lead (0.65 mg/l) detected in 1980. However, 1981 analysis indicates decreasing trend. Potential recharge area for Middendorf aquifer. Septic-tank system receives industrial wastewater containing ink and starch.
Swansea Municipal Sewage Treatment Plant	Lexington	Extent - perimeter of lagoon. Contaminated ground water found at depth of ~10'. Fate - nearby surface water.	Metals	Lagoon	None	Leaky lagoon in flood plain of small stream. Most of the contaminated ground water discharges to stream. Elevated chromium (1.1 mg/l) and lead (1.38 mg/l). High iron (200 mg/l) and nickel (0.4 mg/l) detected.
Vise private well	Lexington	Localized near well.	Fuel oil	Under-ground home heating oil tank	1 private well	Kerosene (243 mg/l) found in private well. Suspected source is neighbor's home oil fuel tank.
Wood Brothers Incorporated	Lexington	300'/25'~25' Fate - nearby surface water.	Acetic acid	Septic tank	1 private well	SCDHEC study determined odor and iron resulting from rapid movement of food processing waste to water table. Company provided well owner with city water.
J.P. Stevens Delta 3 Finishing Plant	Marlboro	Large area of contamination. ~800'/~200'~30' Fate - nearby surface water, possibility of vertical migration.	Nitrate, TDS	Spray Irrigation	None	Monitoring wells at spray field indicate NO ₃ as high as 51 mg/l. Public and private water-supply wells nearby.

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Farmers Mutual Exchange Landfill	Marlboro	Extent - landfill perimeter. Contamination found at depth of ~ 25'. Fate - nearby surface water.	Metals, organics	Landfill	None	One-time burial of pesticide waste. Monitoring continuing.
Marlboro County Landfill DWP-027	Marlboro	Extent - perimeter of landfill at least 15' in depth. Fate - nearby surface water.	Metals	Landfill	None	
Five Forks Landfill DWP-084	Oconee	Lateral extent - southern landfill perimeter. Vertical extent - at least 30'. Fate - nearby surface waters	Metals	Landfill	None	Landfilling activities impacting shallow ground water with chromium and mercury.
Ethyl Corporation	Orange-burg	Lateral extent - multiple plumes present on site. Vertical extent - at least 60'. Fate - vertical migration to Santee Limestone Aquifer.	Organics	Lagoon, spray irrigation	1 public well (non-community)	Supply well has been properly abandoned.
Georgia-Pacific (formerly Holly Hill) Lumber Co.	Orange-burg	Small area of contamination. Vertical extent - at least 55'. Fate - nearby quarry and surface water.	Fuel oil	Spills	None	Wastewater from lagoons contaminating shallow and limestone aquifer with phenol (8.5 mg/l) and COD (400 mg/l). Specific conductivity measured as high as 1100 umhos/cm in shallow wells. Lagoons have been abandoned.
Woodford Grain	Orange-burg	Localized near well. Well depth unknown but >100'.	Lindane	Back-siphoning of pesticide tank into well	1 private well	Well now abandoned. Public water available in area. Lindane (0.494 ppb).
Yarborough private spring	Orange-burg	Lateral extent - 600' Vertical extent - shallow Fate - spring	Gasoline	Under-ground storage tanks	1 spring	Presence of spring in area of very little relief indicates good aquitard to prevent vertical migration of contaminants.
Saugamo Weston	Pickens	Entire contaminated area unknown. (1300'/?/~50') Fate - Towns Creek, potential for vertical migration.	PCB's	Dumps	None	Geohydrologic study conducted by SCDHEC in 1976 concluded shallow and deep contaminated with PCB's, in concentrations of 40 ppb and 7.5 ppb, respectively. Facility operations have been upgraded to prevent subsurface leaks
Anchor Continental Incorporated	Richland	~150'/~25'<10' Fate - Gill Creek	Toluene	Under-ground toluene storage tanks	None	Discovered as seeps into Gill Creek. Recovery well in place. Extent of problem is unknown.
Ashland Chemical Company	Richland	Lateral extent - unknown. Vertical extent - at least 25'. Fate - continued lateral migration, possible vertical migration.	Acid	Pit	None	Unpermitted neutralization pit receiving wash-water containing acid. Monitoring well installed near pit exhibited elevated specific conductivity and depressed pH. Further study recommended.

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Cardinal Chemical Company	Richland	Widespread occurrence of contamination. Fate - discharge to Gill Creek. Vertical migration possible.	Organics, tin	Drum storage site	None	Further study in progress to determine vertical extent of contamination. Facility planning warehouse construction on burial site.
City of Columbia Equipment Services Facility	Richland	Extent - unknown. Fate - nearby stream.	Gasoline	Transmission line leak	None	Strong gasoline odor emitted from sewer drains at Hall Institute. Odor traced upstream to stream bank seep, then to facility. Pipe leak discovered and repaired. Recovery actions for gasoline in stream in progress. Evidence indicates multiple spills over extended period of time.
Derrick private well	Richland	Localized near well.	Motor oil, bacteria	Septic tank, automobile garage	1 private well	Suspected sources upgradient from well are septic-tank/tile-field system and automobile repair garage.
Fairfield Chemical Company	Richland	Lateral extent - adjacent to tile field. Vertical extent - at least 6'. Fate - nearby surface water	Organics	Septic-tank/tile-field	None	Non-permitted discharge of industrial wastewater into septic-tank/tile-field system cause of problem. Consultants presently studying.
Henry private well	Richland	Localized near well.	Organics	Unknown	1 private well	Well contains dichloromethane (14.8 ug/l) and tetrachloroethene (4.1 ug/l). Source unknown.
Lindau Chemical Company	Richland	Extent - ~ 2 acres contaminated to depth of at least 20'. Fate - Congaree River, possible vertical migration.	Ammonia, phenols	Lagoons, overland discharge	None	Geohydrological study completed by SCDHEC in August, 1979, concluded shallow ground water contaminated from phenols (up to 912.0 mg/l), ammonia (252.0 mg/l), and chemical oxygen demand (up to 20,000 mg/l). Flashpoint of ground water measured as 140°F. Specific conductivity was 12,000 umhos/cm. Consulting firm investigating. Facility under consent order.
Robbins and Myers Incorporated	Richland	At least 50'/7/46' Fate - possible vertical migration, possible contamination of area wells.	Metals	Tile-field	None	Improper disposal of metal wastewater into tile field. Further study is planned.
Shell Oil Company (Gervais and Harden)	Richland	Lateral extent - unknown. Vertical extent - ~25'. Fate - toward Five Points area.	Gasoline	Under-ground storage tanks	None	Monitoring well detected 5 mg/l oil, grease, and gasoline in ground water at 23.3'. Soil analysis indicated >17,000 mg/kg in soil at depth of 25' below land surface. The study concluded the soil and ground water were contaminated. The gasoline moving along on top of water-table surface.

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
South Carolina Recycling Disposal (Bluff Road site)	Richland	No definitive plume found. Vertical migration not determined. Fate - Myers Creek and/or unnamed stream, northeast and southeast, respectively.	Organics, metals	Waste chemical storage	1 private well	Preliminary ground-water study completed (1982) by SCDHEC involving 12 wells. Volatile organics appear in all wells. Lateral movement has not been traced. Source is waste chemical storage. Clean-up activities, funded by Superfund are underway. Further study regarding extent and clean-up ground water contamination being developed.
Townsend-Textron Sawchain	Richland	Large area of contamination. ~2000'/~80'/at least 75'. Fate - great potential for vertical migration.	Metals, nitrate	Land disposal of effluent	None	Citizens complaint about dead trees lead to discovery of land disposal of metal-plating waste without treatment. Contaminating shallow aquifer with chromium (41.0 mg/l), cadmium (0.5 mg/l), nitrate (74 mg/l), and cyanide (1.05 mg/l). Specific conductivity of ground water as high as 7100 umhos/cm. Consulting firms investigated. Ground-water recovery system presently in operation. Site is located in Middendorf recharge zone.
Westinghouse Nuclear Fuel Division	Richland	~800'/~600'/~20' Fate - Sunset Lake	Nitrogen, flouride	Lagoon, spray irrigation	None	Discovered after a fish kill below a spring. First phase studied by company with 33 wells has been completed. Further study is planned by the company. Ammonia as high as 909 mg/l, flouride up to 125 mg/l.
Hare private well	Saluda	Localized near well.	Oil	Submersible pump	1 private well	Private well analysis indicated 2.88 mg/l oil (type used in submersible pump).
Lake private well	Saluda	Localized near well.	Bacteria	Septic tank	1 private well	1976 (Water Supply) study found problem limited to fracture system. Chlorination now employed.
Abbott private well	Spartanburg	Localized near well.	Gasoline	Unknown	1 private well	Printing company located near private well. Owner complains of pink stain present in plumbing fixtures. Concerned that facility's septic tank system (receiving dye rinse water) may be contaminating well.
Batchelder-Blasius	Spartanburg	At least 140'/400'/15' Fate - Jimmies Creek.	Metals, waste oil	Landfill	None	Drinking water well indicates a steady increase in TDS and chloride. Further study in progress.
Cartledge private well	Spartanburg	Localized near well.	Gasoline	Unknown	1 private well	

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
National Starch and Chemical Company (formerly Charles S. Tanner Co.)	Spartanburg	600'/800'/36' Fate - unnamed tributary to Two Mile Creek, vertical migration to bedrock aquifer.	Nitrogen, chloride, TDS	Spray irrigation	None	Further study and monitoring indicates continuing upward trends in concentrations. Also, basement aquifer appears to be impacted. Disposal method has been changed.
Dobbin private well	Spartanburg	Localized near well.	Gasoline	Unknown	1 private well	Private well analysis showed gasoline (2.5 mg/l and 1.35 mg/l) in private well.
Geddis private well	Spartanburg	Localized near well.	Gasoline	Unknown	1 private well	Private well analysis detected 3.9 mg/l gasoline.
Groce Laboratories	Spartanburg	Lateral extent - unknown. Vertical extent - 161'. Fate - Maple Creek, bedrock aquifer.	Organics, metals	Spill, landfill, waste pits	1 private well.	An EPA study (April 1981) determined approximately 10 acres of soil was contaminated. Ground-water quality monitored using private wells.
Hoechst Fibers	Spartanburg	Lateral extent - unknown. Vertical extent - at least 33'. Fate - Pacolet River	Metals	Sludge spray field/ sludge disposal site	None	One monitoring well detecting manganese (7.2 mg/l), lead (0.12 mg/l).
International Wire Products	Spartanburg	Shallow groundwater (depth at least 35') contaminated over approximately 2 acres. Fate - Lawson Fork Creek and/or bedrock aquifer.	Organics	Lagoon, overland flow	None	Presence of organics in monitoring wells adjacent to lagoon and overland flow area may be the result of effluent migrating to water table or improper well construction techniques. Further monitoring is needed.
Piedmont Rural Water District	Spartanburg	Lateral extent - localized at well. Vertical extent - greater than 125'. Fate - Unknown.	Organics	Peach orchard	1 public well	One of the producing rock wells for the public water systems contains pesticide solvents. Well has been properly abandoned.
Barnett's Migrant Camp	Sumter	Localized around well Depth unknown.	Endosulfan	Unknown	1 public well (non-community)	Endosulfan 0.8 ug/l.
Booth Farms water-table aquifer	Sumter	Extent - approximately 5 square miles. Fate - nearby surface water.	Nitrate	Fertilizer application, septic tanks, animal feedlots	2 private wells 1 public well	SCDHEC study (1981) determined highest nitrate concentrations (33-250 mg/l) occur in areas where several suspected nitrate sources are concentrated. Monitoring well recently installed in proposed subdivision area (each designed to have individual septic tank systems and shallow well) detected 12 mg/l nitrate. The public well now found to contain tetrachloroethylene (0.29 ug/l).

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Cherryvale Subdivision	Sumter	800'/400'/20-30' Fate - undetermined.	Gasoline, lead, chromium	Spill	6 private wells	SCDHEC study (1981) attempted to determine source. Further study needed to determine lateral and vertical extent of contamination. City water is not available.
Exide Battery	Sumter	1600'/?/~50' Fate - Nasty Branch.	Nickel	Septic tanks, pipe leaks, spills	1 public well	Nickel detected initially in public water-supply well. SCDHEC studied in 1974. Remedial measures included continuous pumpage of contaminated well to remove nickel from shallow aquifer. Water-supply wells and receiving streams continue to be monitored.
Palmetto Pigeon Plant	Sumter	Localized around well. Fate - nearby surface water.	Nitrate	Septic tank	1 public well (non-community)	Public water-supply well contaminated with greater than 10 mg/l nitrates.
Southern Coatings	Sumter	Large area of contamination. ~500'/250'/~20' Fate - Turkey Creek.	Metals	Lagoon	None	No-discharge lagoon indicated contents seeping into ground. Shallow monitoring wells (SCDHEC) indicate ground-water contamination from chromium (0.46 mg/l), iron (170 mg/l), lead (0.82 mg/l) and total dissolved solids (29,400 mg/l).
Sumter County Landfill DWP-091	Sumter	Lateral extent - landfill perimeter. Vertical extent - at least 20'. Fate - Alligator Branch.	Metals	Landfill	None	Monitoring wells installed by SCDHEC as part of Open Dump Inventory program found to contain arsenic, chromium and lead concentrations and constitutes classification of this landfill as an open dump.
Sumter County Landfill (Cook St. site)	Sumter	Lateral extent - landfill perimeter. Vertical extent - at least 16'. Fate - Pocotaligo Swamp.	Metals	Landfill	None	Landfill unmanaged and used for industrial waste disposal.
Wrenn private well	Sumter	Localized near well.	Gasoline	Unknown	1 private well	Gasoline 2.66 mg/l.
Black River Lumber Company	Williamsburg	~100'/~100'/at least 25' Fate - nearby swamp.	Organics, metal	Abandoned dump	None	Abandoned pesticide dump suspected to be source of mysterious "black ooze" surfacing in field. SCDHEC (1981) monitoring wells found high concentrations of pesticides. Determined no threat to nearby public drinking water supply well.

Table 1 (continued). Documented ground-water contamination cases in South Carolina up to December, 1982.

Name of Situation	County	Estimated Extent and Fate of Plume (length/width/depth, if known)	Major Contaminant(s)	Source(s)	Water-Supplies Affected	Remarks
Larimore private well	Williamsburg	Localized near well.	Organics	Unknown	1 private well	Source of dichloromethane 20.8 ug/l unknown. Owner will have well resampled.
Batkins private well	York	Localized near well.	Organics	Surface water infiltration, spills	1 private well	Private well analysis indicates 0.42 ppb chlordane. Well located ~34' from house. Possible source is termite treatment.
Carolina-Transco Propane Company	York	Extent - ~1000'/?/~500' Fate - Atmosphere.	Propane	Storage caverns	1 private well	Liquid propane stored in 400 foot deep caverns escaping through fracture network in bedrock aquifer. Concentrations as high as 6000 mg/l. Monitoring continuing.
Celanese-Celriver Corporation	York	Extent - Multiple plumes overlapping. At least 3000'/~1600'/?>50'. Fate - Catawba River, nearby swales.	Organics, metals	Landfill, waste acid pits, flyash lagoons, chemical handling storage areas	1 public well (non-community)	Monitoring results indicate the shallow aquifer is contaminated with organic compounds and metals. Expansion of monitoring network to include rock wells is planned.
Leonard Chemical Company	York	~50'/?/at least 19' Fate - Ferry Branch, possible vertical migration.	Organics	Drum storage area, waste burial site	None	Recent sampling indicates contamination. Facility under order to continue monitoring. Resampling scheduled to confirm contamination.
Mitchell private well	York	Localized near well.	Gasoline	Underground gasoline storage tank	1 private well	Private well on service station property.
Palmetto Lanes	York	Localized near well.	Nitrates	Abandoned turkey feedlot	1 public well	Suspected source: abandoned turkey feedlot. Nitrates detected ranging between 10-20 mg/l.
Porter private well	York	Localized near well.	Gasoline	Underground gasoline storage tanks	1 private well	Private well contaminated. Located near service station.
Traybor, Incorporated	York	Small area contaminated. Appears to be localized near pond and well.	Taste and odor	Fire protection pond	1 public well	Algicide added to unlined fire-protection pond and associated taste and odor has shown up in drinking water well.

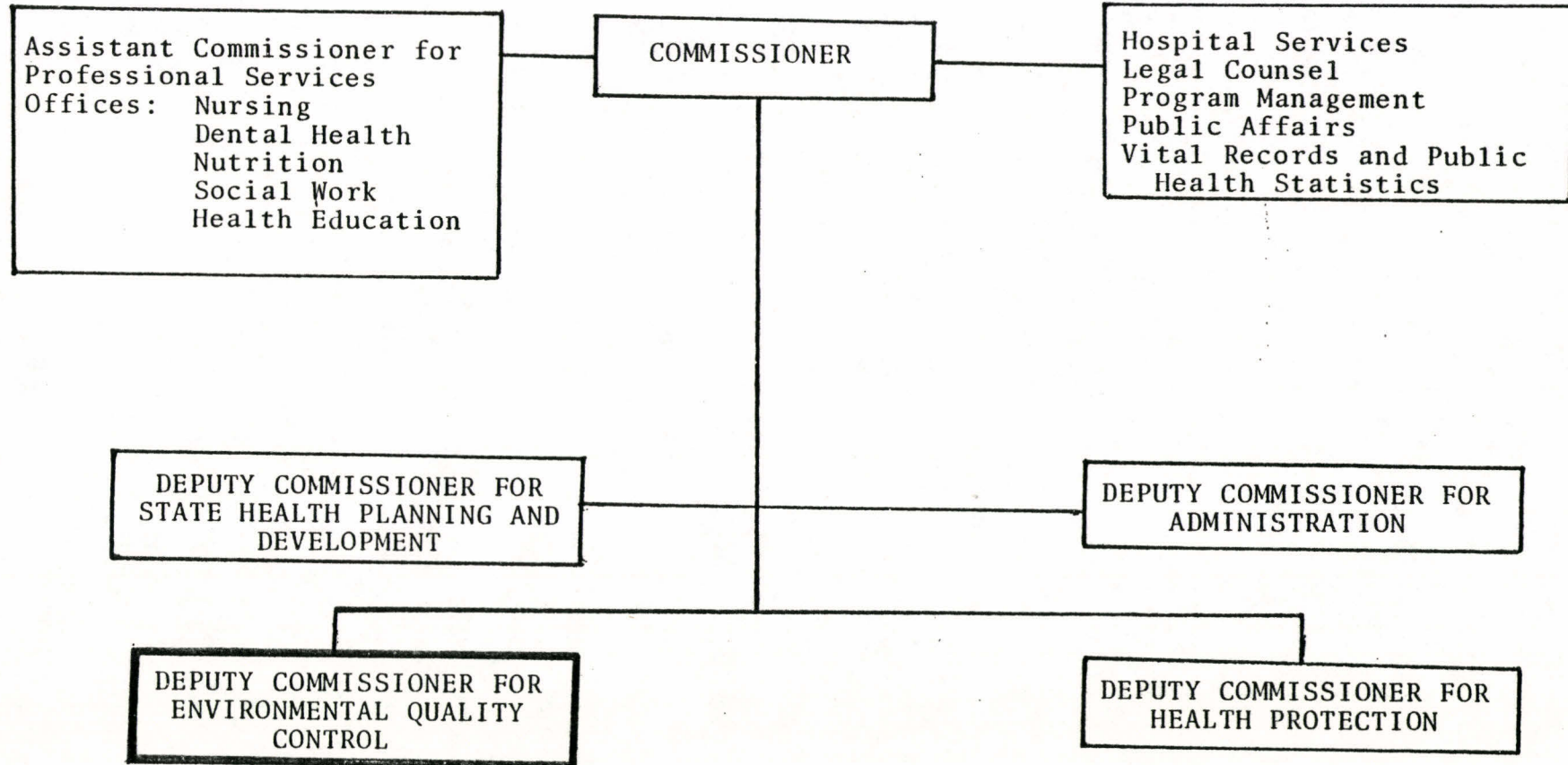
APPENDIX I.

ORGANIZATION AND FUNCTIONS OF THE SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL GROUND-WATER PROTECTION DIVISION.

The table of organization and relationship of the Department of Health and Environmental Control, Environmental Quality Control, and the Ground-Water Protection Division are shown in Attachments 1, 2, and 3. The Ground-Water Protection Division consisting of geologists and technicians, serves as consultants to various regulatory programs in DHEC. Responsibilities include:

1. Review of engineering plans, permits, etc. submitted by permit applicants for all land waste-disposal facilities, e.g., landfills, sludge disposal, spray irrigation;
2. Evaluation and investigation of on-site geohydrological conditions for proposed land waste-disposal facilities;
3. Investigation and reporting of ground-water contamination (including follow-up assistance to agency enforcement personnel as appropriate and required);
4. Review and evaluation of public-water well specifications submitted by permit applicants;
5. Implementation and administration of regulations and enforcement activities of the water well industry as required by amendments to the State Safe Drinking Water Act and Environmental Systems Operators Act.
6. Preliminary design and implementation of state ambient ground-water quality network and data base;
7. Designation of major aquifers and aquifer systems including delineation of critical recharge areas;
8. Maintenance of compliance ground-water quality monitoring data base as necessitated by state and federal programs;
9. Provide technical assistance related to ground-water protection, and as related to the development of public water systems;
10. Implementation of State Underground Injection Control (UIC) program;
11. Conduct limited programs for, federally funded, ground-water research.

SC DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL
BOARD OF HEALTH AND ENVIRONMENTAL CONTROL



Attachment #1
-101-

SOUTH CAROLINA BOARD OF HEALTH
AND ENVIRONMENTAL CONTROL
7 MEMBERS

LEGAL OFFICE
758-5658

COMMISSIONER
SOUTH CAROLINA BOARD OF HEALTH
AND ENVIRONMENTAL CONTROL
ROBERT S. JACKSON, M. D.
758-5443

ADMINISTRATIVE ASSISTANT
C. D. SOUFAS 758-5631

DEPUTY COMMISSIONER
ENVIRONMENTAL QUALITY CONTROL
JOHN E. JENKINS, P. E.
758-5450

SECT., BD. OF CERTIFICATION FOR
ENVIRONMENTAL SYSTEMS OPERATORS
C. R. BEALL, P.E. 758-5430
Exec. Dir., W. R. MOORE

DIVISION OF PROGRAMS MANAGEMENT
DIRECTOR: W.G. GALARDI 758-5631
SECTIONS:
BUDGETS, FINANCE & PERSONNEL
PROGRAMS INTEGRATION & OPERATION
GRAPHICS & WORD PROCESSING

ASSISTANT DEPUTY COMMISSIONER
ENVIRONMENTAL QUALITY CONTROL
ROGER E. DAVIS, P. E. 758-5631

DIVISION OF DISTRICT SERVICES
APPALACHIA I
D. C. JOHNS, P.E. 225-3731
APPALACHIA II
G. E. MILAM, P.E. 242-9850
APPALACHIA III
J. H. TRAVIS, P.E. 596-3800
CATAMBA
A. L. WILLIAMS 285-7461
CENTRAL MIDLANDS
J. L. RUCKER, P.E. 758-4415
LOW COUNTRY
R. M. DIXON 524-9760
LOWER SAVANNAH
G. P. NELSON, P.E. 648-9561
PEE DEE
M. E. KEMBERT, P.E. 662-3522
TRIDENT
J. B. COOK, P.E. 554-5533
UPPER SAVANNAH
W. E. ISEMAN, P.E. 223-0333
WACCAMAW
R. H. TATA, P.E. 448-8407
WATERBURY
R. M. BLACKMON 773-5511

BUREAU OF SOLID & HAZARD WASTES MGMT
CHIEF: R. E. MALPASS, P.E. 758-5677

DIVISION OF ENGINEERING & PROG. DEV.
DIRECTOR: H. W. TRUESDALE, P.E.
SECTIONS: 758-5681
FACILITIES EVALUATION
PROGRAM DEVELOPMENT

DIVISION OF COMPLIANCE & EVALUATION
DIRECTOR: E. M. WILLIAMS, P.E.
SECTIONS: 758-5681
WASTE IDENTIFICATION
EVALUATION, COMPLIANCE, & ENFORCEMENT
EMERGENCY RESPONSE

BUREAU OF ENVIRONMENTAL
QUALITY CONTROL LABS
CHIEF: N. M. HURLEY 758-4986

DIVISION OF ANALYTICAL SERVICES
DIRECTOR: T. C. KURIMAK 758-4986
SECTIONS:
SAMPLE MGT & METAL ANALYSIS
SPECIAL & AUTO ANALYSIS
ENVIRONMENTAL MICROBIOLOGY
ORGANIC ANALYSIS

DIVISION OF AIR QUALITY ANALYSIS
DIRECTOR: G. G. SLICE 758-4702
SECTIONS:
ANALYTICAL
DATA SERVICES
QUALITY ASSURANCE

LAB CERTIFICATION & QUALITY CONTROL
MANAGER: J. E. WATSON 758-4986

BUREAU OF WATER SUPPLY
AND SPECIAL PROGRAMS 758-8649
CHIEF: A. W. REINTZ, III, P.E.

DIVISION OF WATER SUPPLY
DIRECTOR: H. K. BATAVIA, P.E.
SECTIONS: 758-5544
ENGINEERING EVALUATION
COMPLIANCE
ENGINEERING SURVEILLANCE
FLUORIDE PROJECT

DIVISION OF GROUND-WATER PROTECTION
DIRECTOR: D. A. DUNCAN 758-5213
SECTIONS:
FACILITY IMPACT ANALYSIS
SURVEILLANCE & DATA MGMT.

DIVISION OF SHELLFISH & REC. WATERS
DIRECTOR: J. L. HAUSE, P.E. 758-5551
SECTIONS:
SHELLFISH
RECREATIONAL WATERS

BUREAU OF AIR QUALITY CONTROL
CHIEF: OTTO E. PEARSON, P.E. 758-5406

DIVISION OF ENGINEERING SERVICES
DIRECTOR: W. W. CULLER, P.E.
SECTIONS: 758-5406
PREVENTION OF SIGNIFICANT DETERI-
ORATION AND PERMITS
SOURCE EVALUATION

DIVISION OF AIR COMPLIANCE
AND IMPLEMENTATION
DIRECTOR: F. K. STONE 758-5406
SECTIONS:
COMPLIANCE AND ENFORCEMENT
IMPLEMENTATION

BUREAU OF WATER POLLUTION CONTROL
CHIEF: R. LEWIS SHAW, P.E.
SECTION: 758-3877
PLANNING AND DEVELOPMENT

DIVISION OF DOMESTIC WASTEWATER
DIRECTOR: ROBERT W. KING, P.E.
SECTIONS: 758-5067
COMMUNITY
PRETREATMENT/PERMITS
FACILITIES PLANNING
MUNICIPAL
GRANTS MGT & ADMIN.

DIVISION OF INDUSTRIAL AND
AGRICULTURAL WASTEWATER
DIRECTOR: R. G. GROSS, P.E.
SECTIONS: 758-5483
INDUSTRIAL
AGRICULTURAL
NPDES ADMINISTRATION
FEDERAL FACILITIES, CERTIFICATION,
AND ENERGY FACILITIES

DIVISION OF WATER QUALITY
ASSESSMENT AND ENFORCEMENT
DIRECTOR: R. W. SHERER 758-5496
SECTIONS:
ENFORCEMENT
ENVIRONMENTAL ANALYSIS
WATER MONITORING
SPECIAL STUDIES
BIOLOGICAL STUDIES

GROUND-WATER PROTECTION DIVISION

- U.I.C. Program Activities
1. Administration and Program development
 2. Training
 3. Public participation and information

Director, D.A. Duncan

SURVEILLANCE, DATA MANAGEMENT SECTION
Geologist IV, J.M. Ferguson

Program Activities

A coordinated activity to ensure compliance with permit conditions, to investigate unregulated activities and to maintain a data system including:

1. Evaluation of monitoring data submitted by the permittee.
2. Field inspections
3. Performance of ground-water studies
4. Inititiate remedial action (consultation, permit modification, or legal action)
5. Aquifer monitoring
6. Ambient monitoring

U.I.C. Activities

1. Data Management
2. Surveillance and investigation

FACILITY IMPACT ANALYSIS SECTION
Geologist IV, Clyde M. Livingston

Program Activities

A plan review and permit approval activity for new or proposed land-disposal facilities including:

1. Plan review
2. Site evaluations
3. Site (permit) approval
4. Coordination with District personnel
5. Technical assistance

U.I.C. Activities

1. Inventory and assessment of underground injection facilities

ASSESSMENT AND DEVELOPMENT SECTION
Geologist IV, Gary G. Padgett

Program Activities

A plan review activity for public water supply wells and regulating activities of the water well industry.

1. Geotechnical review and evaluation of public water supply wells
2. Regulation of the water well industry
3. Acquisition and evaluation of hydrogeologic data
4. Geophysical logging
5. Technical assistance
6. Special studies coordinator

U.I.C. Activities

1. Identification and designation of aquifers.